National Aeronautics and
Space Administration

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July 13, 2012

QD

Reply to Attn of:

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Subject: Revised Final Status Survey Report, Attachment 17 for the Plum Brook Reactor Facility, Licenses Nos. TR-3, Docket No. 50-30 and R-93, Docket No, 50-185

As a result of comments from the NRC Staff received via electronic mail on April 30, 2012, we have revised the previously submitted Attachment 17, "Buried and Miscellaneous Piping" of the Final Status Survey Report for the Plum Brook Reactor Facility. Our written response to the staff's comments was submitted under a separate cover letter dated May 30, 2012.

Should you have any questions or need additional information, please contact me at NASA Plum Brook Station, 6100 Columbus Avenue, Sandusky, Ohio 44870, or by telephone at (216) 433-3103.

Peter C. Kolb
NASA Decommissioning Program Manager

Enclosure
Plum Brook Reactor Facility Final Status Survey Report, Attachment 17, Buried and Miscellaneous Piping, Revision 1, July 13, 2012

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Plum Brook Reactor Facility

Final Status Survey Report

Attachment 17

Revision 1

Buried and Miscellaneous Piping

FINAL STATUS SURVEY REPORT ROUTING AND APPROVAL SHEET

Document Title: Final Status Survey Report,
Attachment 17
Buried and Miscellaneous Piping

Revision Number: 1

ROUTING

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NASA PBRF DECOMMISSIONING PROJECT CHANGE/CANCELLATION RECORD		
DOCUMENT TITLE: Final Status Survey Report, Attachment 17, Buried and Miscellaneous Piping	**DOCUMENT NO: N/A**	**REVISION NO: 1**
Revision 0: Initial issue of Report		
Revision 1: Added statements in appropriate sections to indicate all MP above the -3' elevation was removed during building demolition; Added photos of pipe removal and disposition above the -3' elevation to Appendix A. Added discussion and results of Sign test, as applicable. Updated and revised Table 6 to show only the remaining BP/MP and Sign test results; Added discussion and results of dose assessment; Updated ALARA Evaluation for the changes in BP/MP inventory; Revised Conclusion to reflect the performance of the Sign test, dose assessment, and other corrections; Updated LOEP for changes; Updated References to include TBD-12-002; Corrected miscellaneous wording and formatting as necessary.		

Form AD-01/3 Rev 1

LIST OF EFFECTIVE PAGES

DOCUMENT NO: N/A **REVISION NO: 1**

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Form AD-01/5 Rev 2

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LIST OF ACRONYMS & SYMBOLS

AF	Area Factor
ALARA	As Low As Reasonably Achievable
BP	Buried Pipe
BP/MP	Buried and Miscellaneous Piping
Co-60	Cobalt 60
CFR	Code of Federal Regulations
cm	centimeters
cpm	counts per minute
CPT	Cold Pipe Tunnel
CRB	Cold Retention Basin
CsI	Cesium Iodide
Cs-137	Cesium 137
CV	Containment Vessel or Critical Value (Sign Test)
DCGL	Derived Concentration Guideline Level
$DCGL_W$	DCGL for average concentrations over a survey unit (Note: the "W" suffix denotes "Wilcoxon")
dpm	disintegrations per minute
EMA	Elevated Measurement Area
EMC	Elevated Measurement Comparison
EMT	Elevated Measurement Test
EPA	US Environmental Protection Agency
Eu-154	Europium 154
FH	Fan House
FSS	Final Status Survey
FSSP	Final Status Survey Plan
FSSR	Final Status Survey Report
ft.	feet
g	gram
gpm	Gallons per minute
H-3	Tritium
HEPA	High Efficiency Particulate Air filter
HL	Hot Lab
HRA	Hot Retention Area
h/y	Hours per year
I-129	Iodine 129
in.	inch
kW	Kilo watt
lb/in^2	pounds per square inch
m^2	square meters
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MW	Mega watt
MDC	Minimum Detectable Concentration
MDCR	Minimum Detectable Count Rate
MP	Miscellaneous Pipe

LIST OF ACRONYMS & SYMBOLS (Continued)

MUR	Mock-Up Reactor
N	number of survey measurements
mrem	millirem
mrem/hr	millirem per hour
mrem/yr	millirem per year
NASA	National Aeronautics and Space Administration
N/A	Not Applicable
NaI	Sodium Iodide
NRC	US Nuclear Regulatory Commission
PBRF	Plum Brook Reactor Facility
PCW	Primary Cooling Water
%	percent
PPH	Primary Pump House
Quad	Quadrant
Rm	room
RB	Reactor Building
ROLB	Reactor Office and Laboratory Building
S+	Test statistic for Sign test
SANS	Sanitary Drain System
SCW	Secondary Cooling Water
SEB	Service Equipment Building
Sr-90	Strontium 90
TBD	Technical Basis Document
WEMS	Water Effluent Metering Station
WHB	Waste Handling Building

1.0 Introduction

This report presents the results of the final status radiological surveys of the Plum Brook Reactor Facility (PBRF) Buried and Miscellaneous Piping (BP/MP). It is Attachment 17 of the PBRF Final Status Survey Report (FSSR).[1] This attachment describes the BP/MP, its operational history, and final condition for the final status survey (FSS). It describes the methods used in decontaminating and surveying the BP/MP and presents the results.

As stated in the PBRF Final Status Survey Plan (FSSP) [NASA 2007], the goal of the decommissioning project is to release the facility for unrestricted use in compliance with the requirements of US NRC 10CFR20, Subpart E. The principal requirement is that the dose to future site occupants will be less than 25 mrem/yr. Subpart E also requires that residual contamination be reduced to levels as low as reasonably achievable (ALARA). The Derived Concentration Guideline Levels (DCGLs) are established for residual surface contamination in the FSSP. Considering the radionuclide mixtures established for areas within the various structures and buildings, gross beta DCGLs range from 11,000 to 38,538 dpm/100cm^2.

The survey measurement results and supporting information are presented to demonstrate that residual contamination levels in each buried or miscellaneous pipe survey unit of the PBRF are below the respective DCGLs. It is also shown that residual contamination has been reduced to levels that are consistent with the ALARA requirement. Therefore, the BP/MP total dose assessment of any given survey unit meets the criteria for unrestricted release as described in the FSSP.

Section 2.0 of this report provides a description and definition of BP/MP. Examples of BP/MP as situated in PBRF buildings are provided.

In Section 3.0, a description of the operational history with radioactive materials is presented for the various groups of BP/MP. Post shutdown decommissioning remediation and survey activities are described.

Section 4.0 presents the FSS design process for the BP/MP. This section includes applicable characterization efforts in support of FSS, DCGL (gross beta or surrogate) and nuclide distribution development. FSS Plan specifics concerning DCGLs are presented.

Survey results are presented in Section 5.0. The survey instrumentation and measurement sensitivities are presented. This section includes a summary of the survey measurements performed in the BP/MP, comparison to DCGLs, tests performed and an evaluation of residual contamination levels relative to the ALARA criterion, and a conclusion with regard to the FSS of BP/MP at PBRF.

Section 6.0 provides the references that were used to support the development of this Attachment.

Section 7 provides supporting information as contained in Appendices. Appendix A contains photos to supplement the text. Appendix B provides BP/MP piping location maps.

[1] The PBRF Final Status Survey Report comprises the report main body and several attachments. This attachment presents survey results for buried and miscellaneous piping and their compliance with the release criterion as established in the PBRF FSSP. The entire final report will provide the basis for requesting termination of Nuclear Regulatory Commission (NRC) Licenses TR-3 and R-93 in accordance with 10CFR50.82 (b) (6).

2.0 Buried and Miscellaneous Piping Description

Buried Piping (BP) is any pipe buried in soil and situated outside the structural foundation of a building, such as storm drains, footer drains, or sanitary lines. Miscellaneous Piping (MP) is any piping, conduit or similar system which does not meet the definition of Buried Piping or Embedded Piping as defined in the PBRF FSSP, but will remain in the structure. Examples of MP include various vents and drain lines, instrument tubing, conduits, and ventilation ducts. It also includes various penetrations in concrete walls and floors that once contained system pipes or valve operator shafts. All piping that was embedded in concrete structures above the -3' elevation was removed during building demolition and surveyed for release and recycled or disposed as radioactive waste. Photographic evidence of this removal during demolition is presented in Appendix A, Exhibit 5.

2.1 Buried and Miscellaneous Piping Systems

The BP/MP is divided into survey units based on similar histories and characterization of residual contamination consistent with the structures associated with these survey units. The configuration of most small diameter BP/MP is such that they could not be readily surveyed with typical building surface measurement detectors. The accessible area of large diameter pipes can be surveyed with typical building surface measurement detectors.

The principal areas of similar nuclide distribution are:

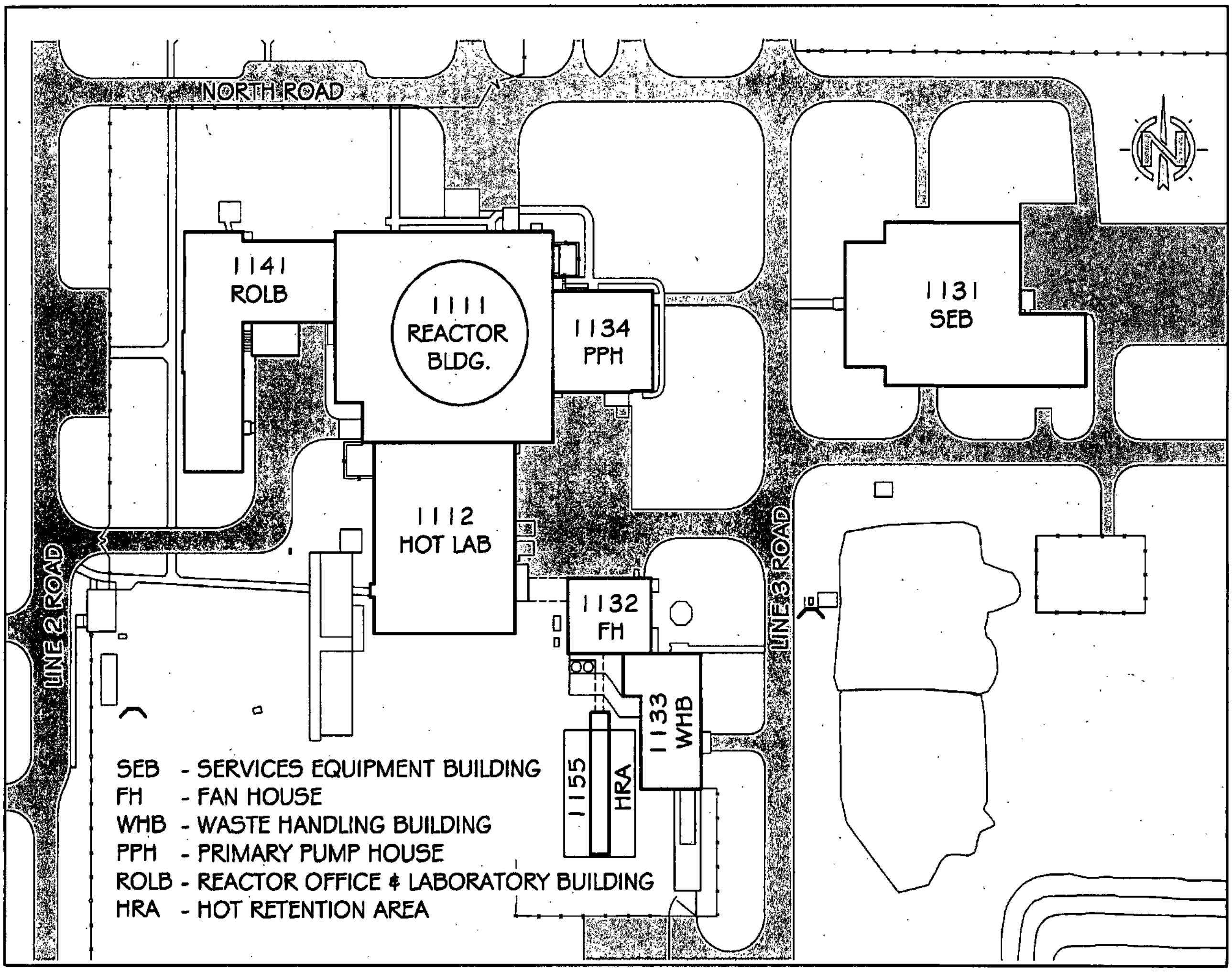
- Waste Handling Building (WHB) MP
- Fan House (FH) MP
- Hot Retention Area (HRA) MP
- Service Equipment Building (SEB) MP
- Reactor Office and Laboratory Building (ROLB) MP
- Hot Laboratory (HL) MP
- Reactor Building (RB) MP
- Containment Vessel (CV) MP
- Primary Pump House (PPH) MP
- Water Effluent Metering Station (WEMS) Outfall Culverts BP
- Pentolite Ditch Crossover Culverts BP
- Sanitary Drain System (SANS) BP

3.0 History of Operations with Radioactive Materials

All BP/MP was characterized to determine if they were impacted by operations. Pipes that were impacted were classified, remediated, and resurveyed for compliance with the release criteria and are included in this Attachment. Pipes that could not be effectively remediated were removed and discarded as radioactive waste. A history of the use of radioactive materials in the various structures associated with BP/MP is provided below. BP/MP not impacted by plant operations (i.e., electrical

conduits, gas lines, etc.) were abandoned in place. Figure 1 shows the relative locations of major PBRF structures.

Figure 1, PBRF Area Showing Reactor Building and Other Support Buildings



3.1 Waste Handling Building

The Waste Handling Building (WHB), with a floor area of 6,750 ft.^{2}, was designed for handling and processing radioactive material. It was located immediately south of and directly connected to the FH. The building contained equipment for processing contaminated water, protective clothing, miscellaneous contaminated trash, or dry active waste (DAW) and equipment and experiment hardware. Waste processing activities included decontamination, waste shipment and recycling. The WHB included laundry facilities for decontaminating protective clothing. It contained operating areas for processing and packaging radioactive waste for offsite shipment. It also contained an evaporator facility for processing high-solids contaminated waste water and work areas for decontaminating reusable equipment and for packaging radioactive waste for storage and shipment. The WHB was designed for operation in

close conjunction with the FH and HRA for processing PBRF radioactive wastes. Survey unit MP-1-1, WHB SANS is included in this Attachment.

3.2 Fan House

The Fan House (FH) was a two level, 6,400 $ft.^2$ (floor area) structure located about 40 meters southeast of the RB and 10 meters east of the HL. The FH first floor elevation is at grade level, corresponding to the RB 0 ft. elevation.

Primary FH functions were collection and processing of exhaust air and contaminated water from the RB and other PBRF buildings. The FH received air from the RB, the CV, reactor experiments, HL, ROLB basement, PPH, WHB, HRA and the Hot Pipe Tunnel (HPT). The incoming air was filtered, monitored, compressed and stored for decay as required, then exhausted through the monitored PBRF Stack located adjacent to the east side of the FH.

All radioactively contaminated water from PBRF was processed in the FH. This included the reactor primary coolant system, the HRA, Cold Retention Basins (CRBs), cooling water systems, the Quadrant and Canal systems, hot sumps and contaminated laundry. Processed waste water was either recycled or stored for decay, but was eventually disposed of as effluent waste water through the WEMS. Survey unit MP-2-1, Room 7 & 8 penetrations is included in this Attachment.

3.3 Hot Retention Area

The Hot Retention Area (HRA) was designed to provide holding capacity for large volumes of radioactively contaminated water generated in PBRF operations. It functioned as a tank farm for storage, holdup and decay of water from the PBRF Hot Drain system. The tanks were housed in the HRA reinforced concrete vault-structure located south of the FH and adjacent to the west side of the WHB. It was 45 ft. wide (east-west) and 90 ft. long (north-south) with the vault floor 25 ft. below grade. The vault roof, or top surface was at grade level, corresponding to the RB 0 ft. elevation. The main HRA vault however, was covered with a four ft. thick earthen berm to provide shielding from gamma radiation emanating from contaminated water in the tanks. Survey units MP-3-1 and MP-3-2, HRA drains are included in this Attachment.

3.4 Service Equipment Building

The Service Equipment Building (SEB), a three-story 25,000 $ft.^2$ (floor area) structure, provided high-purity cooling water for the 60 MW Test Reactor and secondary cooling water for Reactor systems. It also provided service air and instrument air, emergency electric power, heating and process steam and other utilities to the PBRF complex. The SEB housed water processing equipment, air compressors, electrical control equipment, diesel generators for emergency electrical power, the health physics radiochemistry/analytical laboratory and a backup control console with capability to safely shutdown the 60 MW Test Reactor. It also housed personnel offices, an environmental radiological counting laboratory and a chemical test laboratory for water treatment analysis. There were a number of ancillary facilities connected to the SEB. These included the main electrical substation, the water treatment precipitator, two utility air intakes, two diesel fuel oil tanks, a waste oil tank, and the Cold Pipe Tunnel (CPT). Survey unit MP-5-1, CPT drains is included in this Attachment.

3.5 Reactor Office and Laboratory Building

The Reactor Office and Laboratory Building (ROLB) was a three story, 27,000 ft.[2] (floor area) structure located immediately west of the Reactor Building. It contained offices, a conference room, a classroom, a library, repair shops, health physics offices, a first aid facility, instrument calibration shop, new fuel vault, equipment calibration facility, and radiochemistry laboratories. The east wall of the ROLB abutted the west wall of the RB. The buildings were structurally independent. The elevation of the ROLB first floor was at grade level, corresponding to RB 0 ft. elevation (631 ft. above mean sea level). Other major elevations were: basement, -15 ft.; second floor, 12 ft. and roof, 24 ft., 3 in. The ROLB connected to the RB through doorways at the basement, first and second floor levels. Survey unit MP-6-1, ROLB Penetrations and BP-1-8, ROLB Source Well are included in this Attachment.

3.6 Hot Laboratory Building

The Hot Laboratory (HL) was a 15,000 ft.[2] (floor area), three story building located adjacent to the south side of the RB. The HL was designed to handle and analyze highly radioactive materials. Chemical, radiochemical and metallurgical analyses of irradiated experiment specimens such as moon rocks, various nuclear fuel materials and nuclear rocket components were performed in the HL. Activities conducted in the HL also included inspection, disassembly, and modification of reactor core components such as fuel elements, beryllium reflectors (sections and plates), the upper grid assembly and irradiated test materials. The HL contained extensive concrete shielding in walls, floors and ceilings, including high density concrete in the front and side walls of the seven hot cells. Through-wall mechanical manipulators, periscopes, microscopes and other remotely controlled analytical equipment were used to limit personnel exposure to radiation. All HL MP was removed during building demolition (see Appendix A, Exhibit 5) except MP-9-1, Interim Storage conduit lines, which are situated below the -3' elevation.

3.7 Reactor Building

The Reactor Building (RB) was a large, 41,000 ft.[2] (floor area) four story structure which housed the Plum Brook 60 MW Test Reactor, the 100 kW Mockup Reactor (MUR) and associated experimental and test facilities.[2] It was 162 ft. (E-W) by 149 ft. (N-S) at grade level There were two levels below grade (-15 ft. and -25 ft.), the main floor at grade level and a mezzanine floor at 12 ft. The RB was the center of a four-building complex which comprised the heart of the PBRF. It was connected to three major buildings; the HL, PPH and ROLB. The RB construction included the CV, a large cylindrical steel structure which contained the 60 MW Test Reactor. The CV was 100 ft. in diameter, 111 ft. in height at the center and extended from 56 ft. below grade to 55 ft. above grade. It surrounds the Reactor Tank (Pressure Vessel), Bioshield and experiment-test areas. The MUR was located outside the CV in Canal H in the southeast corner of the RB. For the purposes of FSS, the CV and the RB are reported separately. Survey units MP-10-1 through MP-10-6, conduit and penetrations are included in this Attachment. MP-11-2, Lily Pad conduits and penetrations were removed along with the support collar during building demolition (see Appendix A, Exhibit 5).

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[2] The combined floor area of the Reactor Building and CV was 41,324 ft^2. The Reactor Building floor area exclusive of the CV was 30,200 ft^2 and the CV floor area was 11,100 ft^2.

3.8 Primary Pump House

The Primary Pump House (PPH), a 4,200 ft.^{2} (floor area, including a mezzanine) building housed major components of the reactor primary cooling water system. These components included three, 8,650 gpm primary coolant pumps, two large heat exchangers, flow measuring and coolant monitoring equipment, a cleanup system and a fuel element test rig. The PPH shared a common wall with the RB east side and was of thick-walled concrete construction. The walls and roof were designed to provide shielding from gamma radiation originating in the primary coolant and contaminated process equipment. The south and east walls contained sections with removable concrete blocks to provide access for large equipment replacement (heat exchangers, pumps, etc). All PPH MP was removed during building demolition (see Appendix A, Exhibit 5). Survey units BP-1-2 through BP-1-7, PPH Secondary Cooling lines and sump drains are included in this Attachment.

3.9 Drains and Sanitary Piping

Numerous piping systems were buried underground to convey liquids between buildings or to provide a drain path to collection points. Building footer drains collected rain water and ground water in sumps that pumped to the WEMS via various drainage pipes and catch basins. Low-level contaminated water was discharged to the WEMS where it was monitored for radioactivity, and then discharged to the Pentolite Ditch. Three 31" diameter pipes approximately 48 ft. long carried discharge water from the WEMS under Pentolite Road to the Pentolite Ditch (Appendix A, Exhibit 6). Two 31 in. corrugated pipes approximately 74 ft. long carried water in Pentolite Ditch under a section of the ditch that was filled in to allow vehicle access across the ditch. A majority of the storm drainage system has been removed.

During reactor operations, sewage from restroom facilities gravity fed to sewage sumps located in the major buildings. Sewage sumps were located in the Reactor ROLB, the RB, the SEB, the HL, the FH and the WHB. The restroom facility in the Reactor Security and Control Building (RSCB) gravity fed directly to the south sewer lateral (SANS-3). The ROLB, RB and the SEB sumps discharged into the north sewer lateral (SANS-8), located on the north side of those respective buildings. The HL, FH and WHB sumps discharged into the south lateral (SANS-3), located on the south side of the HL and RSCB. Both of these lines tied into an 8 in. sanitary line (SANS-9) located along the west side of Line 2 Road. Sewage gravity flowed south to the south side of Pentolite Road then west to the Pentolite Road lift station. The sewage was then pumped to a 15 in. line along the north side of Maintenance Road. From there, it flowed by gravity to the Taylor Road sewage treatment plant. The Taylor Road sewage treatment plant was removed from service and demolished in 2004 and the sewer system was connected to the municipal waste system. Survey units BP-1-1 and BP-2-1, BP-2-2, and BP-2-3, Sanitary Drains, WEMS outfall, and Pentolite Ditch crossover are included in this Attachment.

4.0 BP/MP Remediation and FSS Design Approach

The initial efforts to reduce the radioactive materials associated with BP/MP involved the removal and disposal of system components, conduits and piping throughout the PBRF buildings. The end result was a facility where the impacted systems which remain are limited to system piping and conduits encased within walls and floors, located under the building slabs, or subsurface runs of buried piping

between buildings. The remaining accesses to these conduits and piping are cut flush, or as near to flush as practicable, with the walls and floors throughout the facility buildings.

Prior to initial radiological survey activities, the piping is inspected using remote camera systems to assure the physical condition of the piping is acceptable for moving radiological detectors through the piping. Before performing any radiological survey activities using in-situ survey equipment, the piping to be surveyed is verified to be free of loose surface contamination by Radiation Protection personnel using full piping length swabs on the pipe interior. This minimizes the potential of loose surface contamination being transported through the piping by the in-situ survey equipment, contaminating the in-situ survey equipment and biasing the piping survey results (Appendix A, Exhibits 1 & 2).

4.1 Remediation

Remediation was performed on the accessible interior surfaces of all radiologically contaminated BP/MP. This involves the use of vacuuming, mechanical cleaning, grit blasting, and high-pressure water. Remediation activities commence with the simplest processes and graduate to more aggressive remediation processes based on representative survey results. This graduated approach minimizes radioactive waste generation and handling, and allows use of those remediation efforts with the lowest safety hazards to be utilized first.

The simplest remediation technique is vacuuming to remove debris deposits from the piping. This method does not appreciably remove corrosion or scale deposits and is rarely the only remediation process required.

Corrosion and scale removal requires mechanical agitation of interior piping surfaces. These methods employ rotating snakes and abrasive or pulverizing heads to mechanically separate radioactivity bearing scale and corrosion deposits from the interior piping. These mechanical processes utilize a vacuum head in close proximity to the piping surfaces being remediated to remove scale and corrosion fragments as they are generated.

When mechanical agitation is insufficient to achieve the remediation goal, aggressive remediation such as grit blasting and/or hydro-lasing may be used. These techniques are used to remove tightly adhered corrosion layers from the piping.

4.2 Final Status Survey Method

Piping interior surfaces are typically surveyed using detectors mounted in engineered sleds. Detector sleds perform two purposes. The primary purpose is to maintain the in-situ geometry consistent with the efficiency determination during field measurements, and the secondary purpose is to facilitate ease of movement through piping and protect the detector from physical damage. The detector is manipulated by technicians through the piping to perform the survey. (Appendix A, Exhibit 3). Sleds are not feasible for some smaller diameter piping and detectors used without a sled are manipulated cautiously to minimize any chance of damage to the detector during field surveys.

Detectors typically used to perform piping surveys are NaI or CsI gamma scintillating detectors of sizes appropriate to the piping size and the physical challenges of the piping runs. These detectors are optimized (windowed) to measure the gamma energies specific to either Co-60 or

Cs-137. A static radiological survey measurement is taken for every foot of pipe traveled. The accessible interior surfaces of large diameter pipes were surveyed using plastic scintillation beta detectors or Geiger-Muller (GM) type frisker probes.

Field measurements in cpm are converted to equivalent beta measurements in dpm/100cm^2 through application of surrogate calculations and piping correction factors. These calculated activity densities are assessed against the applicable DCGL from the FSSP for compliance with the 25 mrem/yr release criterion. When the post-remediation surveys demonstrate the BP/MP remediation goal has been achieved, the surveyed piping is placed in isolation and control and the survey results are documented in the survey unit release record.

4.3 BP/MP DCGLs & Radionuclide Distributions

The PBRF contains numerous pipe runs buried below the surface of site soils or encased in concrete within the site buildings. Examples include piping sleeves in the CV Quadrants and Canals, conduits and tubing in the HL, sanitary drain lines, and drain piping under the PPH floor slab. The BP/MP DCGL values are listed in Table 1. The DCGLs for BP/MP are the same as the structural values [NASA 2007].

Table 1, DCGL Values for Buried and Miscellaneous Piping

Radionuclide	DCGL (dpm/100cm^2)
Co-60	11,000
Sr-90	33,100
Cs-137	40,500
Eu-154	4,500
H-3	9.1E+06
I-129	14,900

Radionuclide distributions and activity ratios for the various building surfaces were developed in TBD-07-001 [PBRF 2007] and modified as described in TBD-11-002 [PBRF 2011]. In some instances, the mixture of radionuclides was found to be unrepresented by the associated building surface mixtures. For these pipes, the piping group activity ratios developed in TBD-06-004 [PBRF 2006] were used. The Cs-137 to Co-60 activity ratio is an important parameter of consideration for evaluation of survey measurements in PBRF BP/MP. When piping surveys are conducted using surface activity measurements, this ratio "controls" the energy window selected for measurement acquisition. This is because one or both of these radionuclides are found in all BP/MP. The Co-60 yields the most restrictive individual nuclide DCGL and the Cs-137 DCGL is the least restrictive DCGL of the gamma emitters that are consistently observed in BP/MP. A summary table of the radionuclide distributions utilized to surrogate field measurements and develop activity profiles for the BP/MP is shown below in Table 2.

Table 2, Radionuclide Activity Profiles							
Bldg / Location	DCGL$_W$ [(1)] (dpm/100cm^2)	Activity Fractions					
		H-3	Co-60	Sr-90	I-129	Cs-137	Eu-154
RB Quad A	13,450	0	0.7499	0	0	0.2501	0
RB Quads B, C, & D	21,470	0	0.3305	0	0	0.6695	0
RB Canals E, F, G & H	30,734	0.012	0.117	0	0	0.871	0
RB-25 ft. el.	14,382	0.075	0.555	0.229	0	0.124	0.018
FH Rooms 7 & 8	10,560	0	1.0	0	0	0	0
WHB SANS	40,500	0.0003	0.043	0.088	0	0.868	0
HRA Drains	11,000	0	1.0	0	0	0	0
CPT Drains	16,240	0	.557	0	0	.443	0
ROLB SANS	23,146	0.265	0.178	0.078	0.013	0.465	0.0013
Interim Storage Lines	38,538	0	0.006	0.158	0	0.836	0
PPH Cooling Water & Drain Lines	11,000	0	1.0	0	0	0	0
WEMS Outfall & PD Crossover	33,673	0	0.0756	0	0	0.9244	0
Sanitary Lines	28,748	0.0004	0.463	0.0034	0	0.489	0.0034

Table 2 Notes:
1. Gross beta DCGL calculated as described in Section 4.4.

4.4 Buried and Miscellaneous Piping Reporting Units

BP/MP surveys were performed in accordance with the Babcock Services Incorporated (BSI)/LVS-002, Work Execution Package (WEP) 05-006 [PBRF 2005] or a PBRF generated Survey Request. The survey instructions described in these documents constitute "Special Methods" as defined in the FSSP for the survey design used in the acquisition of survey measurements. Survey units were developed based on grouping pipes according to function (e.g., conduit, drains, etc.) and associated building area. The data was evaluated using the surface beta DCGLs and activity ratios given in Table 2. The appropriate radionuclide surrogate (Cs-137 or Co-60) was calculated using the following equation:

$$Surrogate_{DCGL} = \frac{1}{\left[\left(\frac{1}{DCGL_{Sur}}\right)+\left(\frac{R_2}{DCGL_2}\right)+\left(\frac{R_3}{DCGL_3}\right)+\dots\left(\frac{R_n}{DCGL_n}\right)\right]}$$

Where: $DCGL_{Sur}$ = Surrogate radionuclide DCGL

DCGL2, 3…n = DCGL for radionuclides to be represented by the surrogate

R_n = Ratio of concentration (or nuclide mixture fraction) of radionuclide "n" to surrogate radionuclide

Where multiple radionuclides are present, the gross beta DCGL is calculated using the following equation:

$$DCGL_{GB} = \frac{1}{\left[\left(\frac{f_1}{DCGL_1}\right)+\left(\frac{f_2}{DCGL_2}\right)+\left(\frac{f_3}{DCGL_3}\right)+\ldots\left(\frac{f_n}{DCGL_n}\right)\right]}$$

Where: $DCGL_{GB}$ = gross beta DCGL

f_n = mixture fraction of radionuclide "n" and

$DCGL_n$ = DCGL of radionuclide "n".

Note 1: If a surrogate radionuclide is used, the "f_n" is equal to the surrogate radionuclide fraction.

The results of the BP/MP radiological surveys are assessed for compliance with the 25 mrem/yr release criterion in units of unity where 1.0 is 25 mrem/year in accordance with the FSSP. The unity calculation is as follows:

$$\frac{C_1}{DCGL_1}+\frac{C_2}{DCGL_2}+\frac{C_n}{DCGL_n} \leq 1$$

Where: $C_{(1\text{-}n)}$ = concentration of radionuclide 1-n and

$DCGL_{(1\text{-}n)}$ = DCGL of radionuclide 1-n.

5.0 Buried and Miscellaneous Piping Survey Results

Post remediation surveys are performed to establish the final status of BP/MP systems after all cleaning and remediation is complete. In small diameter pipe, a one-minute static measurement is obtained inside the pipe at 1 foot increments along its entire length. In large diameter pipe, direct beta measurements are taken where accessible. If any individual measurement exceeds the unity value (>1.0), an area factor (AF) is calculated based on the actual size of the elevated measurement area (EMA) and an elevated measurement comparison (EMC) is performed as described in the FSSP, Section 8.3. The $DCGL_{EMC}$ is calculated as the product of the Area Factor (AF) and the $DCGL_W$. If any EMA is greater than the $DCGL_{EMC}$, additional remediation is performed. If the EMA is less than the $DCGL_{EMC}$, an elevated measurement test (EMT) is performed using the following equation:

$$\frac{\delta}{DCGL_W}+\frac{(average\ concentration\ in\ elevated\ area)-\delta}{(AF)\ (DCGL_W)} \leq 1.0$$

Where: δ is the average residual activity concentration in the survey unit.

If more than one EMA is found in a survey unit, the second term in the EMT equation is calculated for each and summed with the first term to perform the unity rule calculation for the EMT. Results of the $DCGL_{EMC}$ and EMT calculations are presented in Table 7.

5.1 Detector Efficiencies and MDCs

The detectors utilized for a majority of BP/MP surveys were gamma scintillating detectors constructed of NaI or CsI crystals with photo-multiplier tubes in a single housing purchased from various vendors. These detectors were optimized during calibration to measure gamma energies representative of Co-60 or Cs-137 gamma energies with the use of discriminator settings (windowing). The accessible interior surfaces of large diameter pipes were surveyed using plastic scintillation beta detectors or GM type frisker probes.

For gamma detectors, the calibrated detectors are assigned specific efficiencies for each unique combination of detector, sled, and nuclide of concern, co-axial cable length and pipe diameter. An example of how these unique efficiencies are determined for a 4 in. pipe with a predominately Cs-137 nuclide mixture follows:

- A sled suitable for the physical layout of the 4 inch pipe(s) to be surveyed is selected to be used with detector.
- A 4 ft. section of 4 in. clean piping (mockup) is loaded with a large, flexible, conformal single nuclide source which has a vendor certified (NIST traceable), homogenous activity deposition of Cs-137 activity across its surface area. The source is loaded inside the 4 in. clean pipe section, in continuous contact with the pipe's inside diameter.
- The detector is fitted into the sled and inserted into the 4 inch pipe containing the conformal Cs-137 source. The detector is centered on the middle of the Cs-137 source (Photographs of a detector-sled-pipe and cable setup are located in Appendix A, Exhibit 4 of this attachment).
- A series of counts are collected and a unique efficiency is calculated for the detector-sled-pipe combination.

After the efficiency determination is completed, it is used to calculate MDCs and MDCRs for that detector-pipe combination. All calibrations, efficiencies and MDC/MDCR calculations are entered into the detector history files and referenced for converting field measurements in counts per minute to activity measurements in disintegrations per minute per 100 centimeters squared. Detector sensitivity is verified to be acceptable for use in accordance with the FSSP, Section 6.5. Table 3 lists typical efficiencies and MDCs for several common pipe sizes utilized during surveys of the BP/MP presented in this Attachment.

Table 3, Typical Detector Efficiencies and MDC_{Static}

Pipe Diameter (Inches)	Co-60 MDC (dpm/100cm^2)	Co-60 Efficiencies	Cs-137 MDC (dpm/100cm^2)	Cs-137 Efficiencies
1.0	6,687	0.0006	12,247	0.00048
2.0	5,234	0.00024	10,190	0.00026
4.0	4,973	0.00032	4,280	0.00043
6.0	3,406	0.00018	1,206	0.00051

For beta measurement detectors, the detection sensitivities must be sufficient to meet the required action levels for the MARSSIM class of each survey unit. The minimum detection

sensitivities for scan and static beta measurements were developed in Survey Request (SR) 361 and are shown in Table 4 below.

Table 4, Typical Detection Sensitivities of BP/MP Beta Detectors				
Detector Model	Detector Efficiency (c/d)	MDC_{scan} (dpm/100cm²)	Net cpm Equivalent to $DCGL_W$	MDC_{static} (dpm/100cm²)
LMI 44-116	0.280	3,176	2000	723
LMI 44-9	0.146	3,140	200	3,808

Table 4 Notes:
1. Static count time of 1 minute
2. 44-116 background count rate of 200 cpm
3. 44-9 background count rate of 125

5.2 Final Status Survey Results

The BP/MP remediation and survey campaign began in 2005 and continued through the decommissioning effort at PBRF. As a result of this remediation and survey campaign, 24 survey units of BP/MP were remediated and surveyed. Table 6 provides a summary of the BP/MP survey results. Each survey unit is identified with a Survey Unit ID, a short description of the survey unit, the survey unit's size, MARSSIM Class, and the number of survey measurements acquired in the survey unit. For each survey unit, the appropriate DCGL, maximum activity, EMC Test result, mean activity and standard deviation of the survey measurements for that survey unit is listed. An affirmation that the average activity in each survey unit is less than the $DCGL_W$ is given and the result of the Sign test, if performed. The last column references the appropriate Appendix B Map number for the survey unit.

A static measurement is obtained for each foot of BP/MP for all survey units, except the sanitary (SANS) system[3] and other large diameter piping. The number of measurements (N) far exceeds the sample density of a typical building surface survey unit. In addition, background activity is not subtracted from BP/MP surface activity measurements since no background study was performed for the numerous pipe size geometries and configurations. However, most of the survey measurements fall within typical background ranges for the various detector and pipe geometry combinations observed during detector efficiency determinations, or would be significantly reduced if typical background values were applied. Table 5 shows the range and average typical gamma background count rates obtained inside the various pipe mockups and associated average gamma background activity.

[3] The sanitary (SANS) system was an active system at the time of the survey. The flow of water was temporarily halted using an inflatable bladder. The first two feet of pipe in each direction at each manhole was the only accessible portion of the system.

Table 5, Typical Detector Background Activity			
Radionuclide	**Range (cpm)**	**Average (cpm)**	**Average Activity ($dpm/100cm^2$)**
Co-60	2-6	4.1	5,840
Cs-137	9-13	10.7	7,345

The average background count rate for beta survey measurements was 196.4 cpm. This is equivalent to a background beta activity of 1,708 $dpm/100cm^2$.[4]

The Sign test was performed on each survey unit where the maximum activity of any single measurement exceeded the $DCGL_W$. The Sign test is used to test the null hypothesis, H_0: The median concentration of residual radioactivity in the survey unit > $DCGL_W$. In survey units where all of the measurements are less than the $DCGL_W$, the null hypothesis will always be rejected and the Sign test is not required.

To conduct the Sign test, each static measurement is subtracted from the $DCGL_W$. The result is a positive or negative number. Any result that is exactly zero is discarded and the number of measurements (N) is reduced accordingly. The number of positive results, which represents values below the $DCGL_W$, are summed to form the test statistic, S+. This value is compared to the critical value (CV) obtained from NUREG 1575, Appendix I, Table I.3 [USNRC 2001] using the survey design parameter for the Type I decision error probability ($\alpha = 0.05$) and the corresponding N. If N exceeds the Table I.3 maximum, the CV is calculated as follows:

$$\text{Critical value} = \left(\frac{N}{2}\right) + \frac{z}{2}\sqrt{N}$$

Where z is the (1-α) percentile of a standard normal distribution.

All BP/MP survey units where any single measurement exceeded the $DCGL_W$, passed the Sign test (S+ > CV), as shown in Table 6. The null hypothesis is rejected in favor of the alternate hypothesis, H_a: The median concentration of residual radioactivity in the survey unit < $DCGL_W$.

[4] This value was calculated using detector data from the FSS/Characterization Survey Form, CHS-3681, October 26, 2011. E_s 0.34, $E_i = 0.338$, $E_t = 0.115$

Table 6, Buried and Miscellaneous Piping Survey Results

Survey Unit	Survey Unit Description	Survey Unit size (m^2)	Class	No. of Measurements	$DCGL_W$ (1) (2)	Maximum Activity (1)	Test Result: Maximum <$DCGL_W$	Mean Activity (1)	Standard Deviation (1)	Mean Activity <$DCGL_W$	Sign Test S+ > CV	Appendix B Map Number
BP-1-1	Sanitary System Drain SANS-11	2.24	1	23	28,748	24,148	Yes	14,086	4,312	Yes	N/A	15
BP-1-2	PPH-101 Secondary Cooling Water	14.0	1	20	11,000	6,567	Yes	4,004	1,012	Yes	N/A	19
BP-1-3	PPH-102 Secondary Cooling Water	14.6	1	16	11,000	5,599	Yes	3,718	836	Yes	N/A	20
BP-1-4	RPHD-1 PPH Sump Drain	1.7	1	17	11,000	13,178	No (3)	6,578	3,223	Yes	Yes	21
BP-1-5	RPHD-2 PPH Sump Drain	0.4	1	8	11,000	6,589	Yes	5,093	1,199	Yes	N/A	22
BP-1-6	ED-1 PPH Sump Drain	0.4	1	10	11,000	10,967	Yes	4,136	2,805	Yes	N/A	23
BP-1-7	RP-01 PPH Sump Drain	0.5	1	11	11,000	10,923	Yes	6,600	2,068	Yes	N/A	24
BP-1-8	ROLB Source Well	20.23	1	32	11,000	2,860	Yes	2,255	308	Yes	N/A	25
BP-2-1	Pentolite Ditch Crossover	109.3	1	145	33,673	16,837	Yes	12,459	1,684	Yes	N/A	17
BP-2-2	WEMS Outfall	110.0	1	146	33,673	11,112	Yes	7,071	1,347	Yes	N/A	18
BP-2-3	Sanitary System Drain SANS-9	3.16	3	40	28,748	2,452	Yes	1,328	780	Yes	N/A	19
MP-1-1	WHB SANS	4.3	1	44	40,500	21,384	Yes	12,555	4,172	Yes	N/A	1
MP-2-1	Fan House Rooms 7 & 8 Penetrations	7.6	1	52	10,560	9,050	Yes	2,323	1,341	Yes	N/A	2
MP-3-1	HRA 0' Floor Drains	9.82	1	101	11,000	27,280	No (3)	5,555	3,465	Yes	Yes	3
MP-3-2	HRA Vault Perimeter Drains	21.1	1	225	11,000	3,707	Yes	2,574	473	Yes	N/A	4
MP-5-1	CPT Floor Drains	2.043	1	21	16,240	11,043	Yes	7,795	1,949	Yes	N/A	5
MP-6-1	ROLB SANS Penetrations	0.85	1	10	23,146	27,312	No (3)	15,739	7,175	Yes	Yes	6
MP-9-1	Interim Storage Lines	15.13	1	311	38,538	146,830	No (3)	33,143	8,864	Yes	Yes	7
MP-10-1	RB -25' 2" Conduits	0.36	1	8	14,382	8,960	Yes	1,470	326	Yes	N/A	8
MP-10-2	RB -25' 1.5" Conduits	2.995	1	81	14,382	15,676	No (3)	7,191	2,876	Yes	Yes	9

Table 6, Buried and Miscellaneous Piping Survey Results

Survey Unit	Survey Unit Description	Survey Unit size (m^2)	Class	No. of Measurements	$DCGL_W$ (1) (2)	Maximum Activity (1)	Test Result: Maximum <$DCGL_W$	Mean Activity (1)	Standard Deviation (1)	Mean Activity <$DCGL_W$	Sign Test S+ > CV	Appendix B Map Number
MP-10-3	Quad A Penetrations	5.17	1	52	13,450	27,438	No (3)	10,626	6,053	Yes	Yes	10
MP-10-4	Quad D Penetrations	64.2	1	77	21,470	28,985	No (3)	12,882	5,797	Yes	Yes	11
MP-10-5	Quads B&C Penetrations	7.21	1	75	21,470	31,132	No (3)	12,453	6,656	Yes	Yes	12/13
MP-10-6	Canal E Penetrations	1.167	1	8	30,734	3,073	Yes	2,151	615	Yes	N/A	14

Table 6 Notes:
1. Activity is dpm/100cm^2.
2. Gross beta DCGL calculated as described in Section 4.4.
3. EMT performed. Refer to Table 7.

Table 7, BP/MP EMT Results							
Survey Unit	EMA ID	Measured Activity (Unity Value)	Size of Elevated Area (m^2)	Area Factor	$DCGL_W$ (1) ($dpm/100cm^2$)	Average Activity in Survey Unit (Unity Value)	EMT Unity Value
MP-3-1	EMA1	1.002	.0973	40.2	11,000	0.505	0.571
	EMA2	1.876	.0973	40.2			
	EMA3	1.76	.1946	40.2			
MP-6-1	EMA1	1.15	0.12	40.2	23,146	0.68	0.57
MP-9-1	EMA1	1.23	0.924	11.97	38,538	0.86	0.884
	EMA2	1.06	0.632	16.87			
	EMA3	1.10	0.341	30.01			
	EMA4	1.11	0.486	21.20			
MP-10-2	EMA1	1.09	0.04	40.2	14,382	0.50	0.505
MP-10-3	EMA1	1.49	0.073	40.2	13,450	0.79	0.774
	EMA2	1.95	0.073	40.2			
	EMA3	1.80	0.12	40.2			
	EMA4	1.43	0.097	40.2			
	EMA5	1.48	0.097	40.2			
	EMA6	1.26	0.584	18.07			
	EMA7	1.30	0.061	40.2			
	EMA8	1.13	0.438	23.6			
MP-10-4	EMA1	1.35	0.015	40.2	21,470	0.60	0.634
	EMA2	1.35	0.015	40.2			
	EMA3	1.26	0.015	40.2			
	EMA4	1.26	0.015	40.2			
MP-10-5	EMA1	1.30	0.048	40.2	21,470	0.58	0.622
	EMA2	1.23	0.048	40.2			
	EMA3	1.03	0.024	40.2			
	EMA4	1.45	0.015	40.2			
	EMA5	1.16	0.015	40.2			
	EMA6	1.06	0.015	40.2			
BP-1-4	EMA-1	1.198	0.097	40.2	11,000	0.598	0.556
	EMA-2	1.15	0.097	40.2			

Table 7 Notes:
1. Gross beta DCGL calculated as described in Section 4.4.

5.3 Dose Assessment

A dose assessment was performed for the remaining MP and BP using calculation methods and assumptions consistent with what was used for embedded piping as reported in the FSS Plan as a result of comments received by the NRC. Upon their review of Attachment 17, Revision 0, the NRC Staff had identified two major concerns:

- The introduction of miscellaneous piping is outside the scope of the FSS Plan and this may be an un-reviewed safety issue requiring a license amendment.

- NASA has not provided an adequate description of the methodology and approach for MP and BP. Thus, NRC Staff cannot determine if miscellaneous piping meets 10CFR20 Subpart E criteria for unrestricted use.

Following discussions with the NRC Staff, NASA has agreed to perform additional actions and evaluations to address the Staff concerns and to strengthen the demonstration that BP and MP meet the 10CFR20 Subpart E criteria. The dose to future site occupants is calculated in TBD-12-002 [PBRF 2012] for selected MP and BP using the piping contamination levels measured in the recent FSS as reported in this Attachment. The objective is to demonstrate that the dose from BP/MP is well below the 25 mrem/y dose criterion when added to the dose contribution from residual contamination measured in the structures or land areas in which the piping resides. The six survey units with the highest dose potential were selected for this evaluation. They include four MP survey units and two BP survey units with calculated doses ranging from 3.7E-11 to 1.72E-01 mrem/yr.

The results for MP show that the calculated doses are quite low even for the cases with the largest number of pipes (pipe clusters). The eleven-pipe cluster in The Quad C wall contains the highest concentration of MP found and it is assumed that the maximum measured concentration in the MP-10-5 survey unit, 31,132 dpm/100-cm^2 is uniformly distributed throughout the piping. The calculated dose from this configuration is 2.6E-03 mrem/yr. This result represents the worst case upper bound on the dose to a future building occupant from MP.

The results for the BP are calculated for the Resident Farmer scenario and an Intruder scenario. The Resident Farmer results are obtained using MicroShield (2340 h/y occupancy) when a future site occupant occupies an area in the center of the Pentolite Ditch Crossover piping. Under these assumptions, the annual dose from BP is 4.66E-05 mrem/yr. Doses calculated under the Intruder scenario using RESRAD (100 h/y occupancy) assumes that an intruder or worker occupies an area in the center of the Pentolite Ditch Crossover where the soil, contaminated by the disintegration of the pipe, is brought to the surface. Under these assumptions, the highest annual dose from BP is 1.72E-01 mrem/yr (BP-2-1).

These results demonstrate that use of the structural DCGLs for the FSS of BP and MP remaining 3' below grade after building demolition and site restoration is an acceptable and very conservative approach.

5.4 Quality Control

Replicate field measurements were not consistently performed by the BP/MP contractor as required by the FSSP, Section 12.7.1. However, replicate scans and static measurements were performed on the survey units shown in Table 8 below. A total of 43 replicate measurements were taken of 498 static measurements in 7 of the 25 BP/MP survey units. At least 5% of each

of the survey units was rescanned. The results of these QC measurements met the acceptance criteria given in the FSSP, Section 12.7.1.

Table 8, Quality Control Replicate Measurements			
Survey Unit	**Survey Request Number**	**Number of Replicate Measurements**	**Total Number of Measurements Represented by Replicate**
BP-1-1	SR-292	2	23
BP-2-1	SR-181/182	15	145
BP-2-2	SR-190	9	146
BP-2-3	SR-361	2	40
MP-10-1	SR-333	2	8
MP-10-2	SR-334	9	81
MP-11-2	SR-341	4	55

The quality of BP/MP radiological survey measurements was assured by the application of quality control protocols delineated in the implementing procedures and review criteria for BP/MP field activities, detector quality control documents, and survey assessment. All activities are directed by PBRF approved procedures.

All instrument and detector calibrations are performed by a qualified off-site vendor(s) using NIST traceable standards. After calibration and prior to use, background and source quality control charts are developed for each detector with an acceptable range of ±20% for the established source and background count rates. A performance check is done prior to and after any efficiency determination or field survey measurements. If a detector fails the pre-use source check it is removed from service. If a detector fails a post use source check, the cause is investigated and the data is reviewed for acceptability. If the cause of the failure cannot be determined, the survey is re-performed.

Efficiency determinations are performed using NIST traceable sources. Drawings accompany all efficiency determinations which depict the in-situ geometry, detectors, radioactive sources and other specifics allowing accurate reproduction of efficiency determinations at future dates.

5.5 ALARA Evaluation

It is shown that residual contamination in the BP/MP has been reduced to levels that are ALARA, using a method acceptable to the NRC. The NRC guidance on determining that residual contamination levels are ALARA includes the following:

> "In light of the conservatism in the building surface and surface soil generic screening levels developed by the NRC, NRC staff presumes, absent information to the contrary, those licensees who remediate building surfaces or soil to the generic screening levels do not need to provide analyses to demonstrate that these screening levels are ALARA. In addition, if residual radioactivity cannot be detected, it is presumed that it had been

reduced to levels that are ALARA. Therefore, the licensee does not need to conduct an explicit analysis to meet the ALARA requirement."[5]

Screening level values published by the NRC for the mix of radionuclides in structural surface residual contamination potentially present in the BP/MP are shown in Table 9. Since individual radionuclide activity concentrations are not measured in the FSS of BP/MP, a direct comparison of residual contamination levels to individual radionuclide screening level values is not possible. A comparison can be made to an appropriate gross beta activity DCGL. Since the BP/MP nuclide mixture varies with its associated structure, area weighted average nuclide fractions were calculated to develop a screening level value that is equivalent to a gross activity DCGL using the equations in Section 3.6 of the FSS Plan.[6] The activity fractions listed in Table 9 were used in the calculation. The screening level equivalent DCGL for the BP/MP is calculated to be 13,935 dpm/100cm^2.

The best estimate of average residual total surface beta activity in the BP/MP is the mean of the 1,533 measurements. This is 8,074 ±6,933 dpm/100cm^2 (one standard deviation). The upper limit of the confidence interval about the mean at the 95% probability level is 8,421 dpm/100 cm^2.[7] This value is well below the screening level gross beta activity DCGL of 13,935 dpm/100 cm^2.

Table 9, Screening Level Values for BP/MP and Radionuclide Activity Fractions

Radionuclide	Screening Level Value (dpm/100cm^2)	Activity Fraction (%) (1)
H-3	1.2 E+08 (2)	0.0012
Co-60	7.1E+03 (2)	0.336
Sr-90	8.7E+03 (2)	0.0087
I-129	3.5E+04 (2)	0.00003
Cs-137	2.8E+04 (2)	0.654
Eu-154	1.2E+04 (3)	0.0002

Table 9 Notes:
1. Activity fractions are calculated as the area weighted average of all survey units.
2. Values from NUREG-1757 Vol. 2, Table H.1 [USNRC 2006].
3. Values from NUREG/CR-5512, Vol. 3, Table 5.19 [SNL 1999]. These are 90th percentile values of residual surface activity corresponding to 25 mrem/yr to a future building occupant.

[5] This guidance was initially published in Draft Regulatory Guide DG-4006, but has been reissued in NUREG-1757 Volume 2, Appendix N [USNRC 2006].

[6] The equivalent screening level gross activity DCGL is calculated using the equations in section 3.6 of the FSS Plan [NASA 2007].

[7] The upper limit of the confidence interval, 95% probability level value, is calculated as: UL = mean + 1.96 $\sigma/\sqrt{n}$, where n = 8,914 systematic measurements.

5.6 EPA Trigger Values

The PBRF license termination process includes a review of residual contamination levels in groundwater and soil, as applicable, in accordance with the October 2002 Memorandum of Understanding (MOU) between the US NRC and the US Environmental Protection Agency (EPA). Concentrations of individual radionuclides, identified as "trigger levels" for further review and consultation between the agencies, are published in the MOU [USEPA 2002]. However, no soil survey units are included in the survey of the BP/MP. It is also noted that groundwater is not within the scope of the BP/MP survey effort. Therefore, comparison with EPA Trigger Levels is not applicable to BP/MP survey measurement results.[8]

5.7 Conclusions

The results presented above demonstrate that the BP/MP satisfies all FSS Plan commitments and meets the release criteria in 10CFR20 Subpart E. The principal conclusions are:

- Static gamma radiation measurements were performed at 1 foot intervals on accessible portions of all BP/MP Class 1 survey units. Direct surface beta measurements were made on accessible portions of Class 3 active sanitary sewer system (SANS) piping.
- All survey units' mean fixed measurement results are below the $DCGL_W$.
- Investigations were performed following observation of elevated activity in 8 survey units. As a result of these investigations, elevated measurement comparisons and elevated measurement tests were performed and all were satisfactory. The Sign test was performed on all survey units where elevated activity > DCGL was observed and all results were satisfactory.
- The classification of Miscellaneous Pipe (MP) is not defined in the FSS Plan. MP was surveyed using the same criteria as BP.
- Residual surface activity concentration measurement results are shown to be less than NRC screening level values - demonstrating that the ALARA criterion is satisfied.
- The highest potential dose to a future site occupant from BP/MP is 1.72E-01 mrem/yr based on dose modeling performed under TBD-12-002 [PBRF 2012]. This demonstrates that the use of structural DCGLs for BP and MP is an acceptable approach for all piping remaining.
- A majority of MP was removed from the associated structures during the decontamination phase of the project. All MP situated above the -3ft elevation was removed and disposed of as radioactive waste or surveyed to no detectable activity standards and released for recycling. (See Appendix A, Exhibit 5).

[8] The PBRF license termination process includes a review of residual contamination levels in groundwater and soil, as applicable, in accordance with the October 2002 Memorandum of Understanding (MOU) between the US NRC and the US Environmental Protection Agency (EPA) [USEPA 2002]. Concentrations of individual radionuclides, identified as "trigger levels" for further review and consultation between the agencies, are published in the MOU. Since these trigger levels are only applicable to the PBRF for residual soil and water concentrations, they do not apply to the Buried and Miscellaneous Piping results provided in this attachment.

6.0 References

NASA 2007 — NASA Safety and Mission Assurance Directorate, *Final Status Survey Plan for the Plum Brook Reactor Facility,* Revision 1, February 2007.

PBRF 2005 — Plum Brook Reactor Facility Work Execution Package, *Decontamination & Radiological Survey of Embedded and Buried Piping Systems,* PBRF-WEP-05-006, November 2005.

PBRF 2006 — Plum Brook Reactor Facility Technical Basis Document, *Activity Ratios of Radionuclides in Embedded and Buried Piping,* TBD-06-004, October 2006.

PBRF 2007 — Plum Brook Reactor Facility Technical Basis Document, *Adjusted Gross DCGLs for Structural Surfaces,* PBRF-TBD-07-001, June 2007.

PBRF 2011 — Plum Brook Reactor Facility Technical Basis Document, *Re-Evaluation of Structure DCGLs and Uranium Activity Fractions,* PBRF-TBD-11-002, January 2012.

PBRF 2012 — Plum Brook Reactor Facility Technical Basis Document, *Dose Assessment for Miscellaneous and Buried Piping,* TBD-12-002.

SNL 1999 — Sandia National Laboratories (SNL), for US Nuclear Regulatory Commission, *Residual Radioactive Contamination From Decommissioning, Parameter Analysis,* NUREG/CR-5512, Vol.3, October 1999.

USEPA 2002 — Memorandum of Understanding, US Environmental Protection Agency and US Nuclear Regulatory Commission, *Consultation and Finality on Decommissioning and Decontamination of Contaminated Sites*, October 9, 2002.

USNRC 2001 — *Multi-Agency Radiation and Site Survey Investigation Manual* (MARSSIM), NUREG 1575, Revision 1, June 2001.

USNRC 2006 — US Nuclear Regulatory Commission, *Consolidated Decommissioning Guidance*, NUREG-1757, Vol. 1, Rev.2, September 2006.

7.0 Appendices

Appendix A – Exhibits

Appendix B – Buried and Miscellaneous Piping Location Maps

Plum Brook Reactor Facility

Final Status Survey Report

Attachment 17

Buried and Miscellaneous Piping

Revision 0

Appendix A

Exhibits

List of Exhibits

Exhibit 1, Exhibit 1, Video Inspection and Cleaning of Buried and Miscellaneous Piping

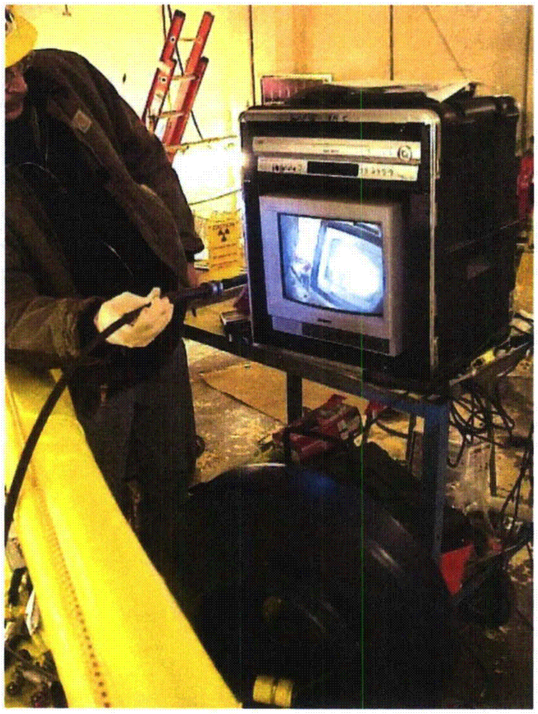
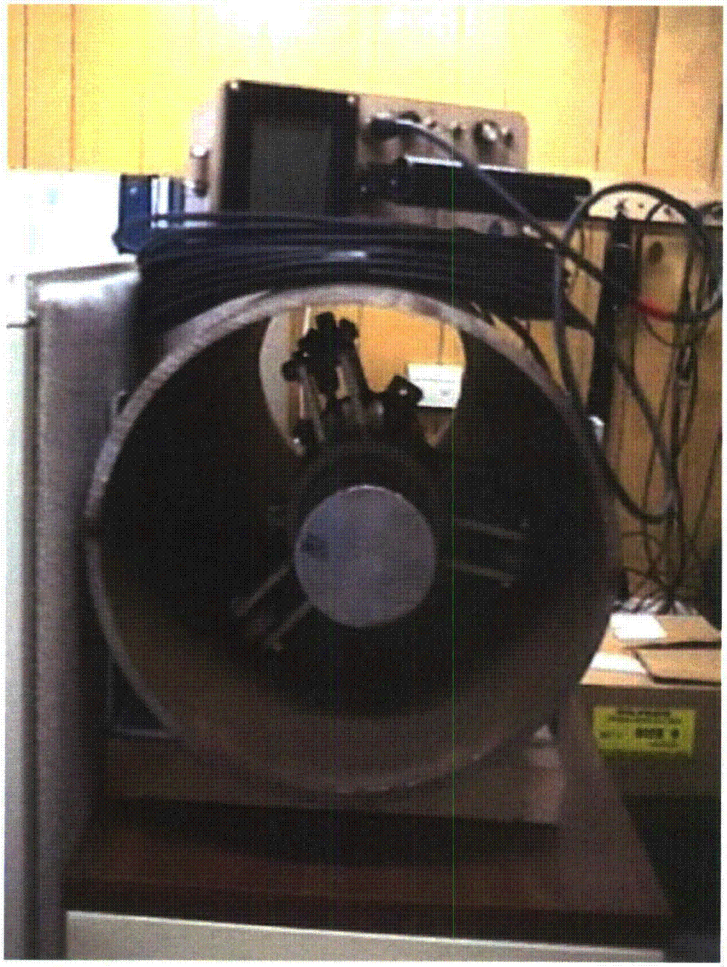


Exhibit 2, Typical Pipe Survey Sled

Exhibit 3, Buried and Miscellaneous Piping Survey

Exhibit 4, Detector-Sled-Pipe and Cable Mock-up



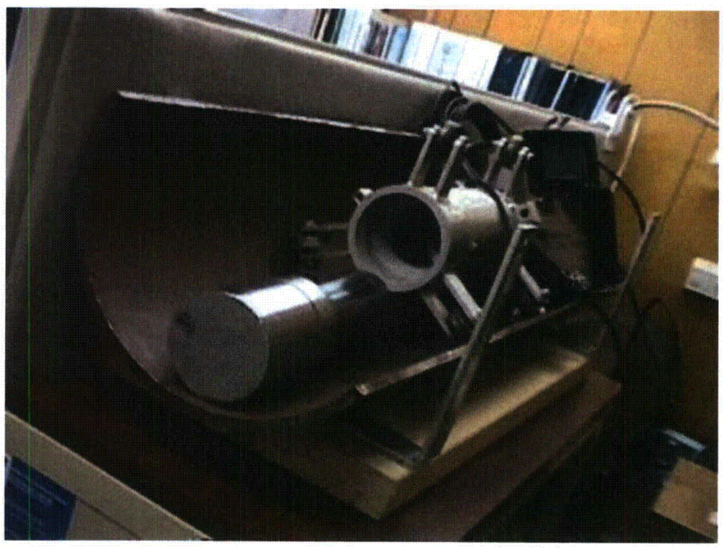
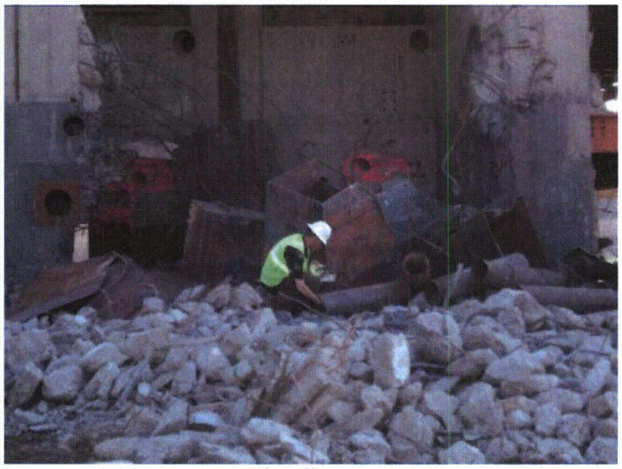


Exhibit 5, MP Removed During Demolition

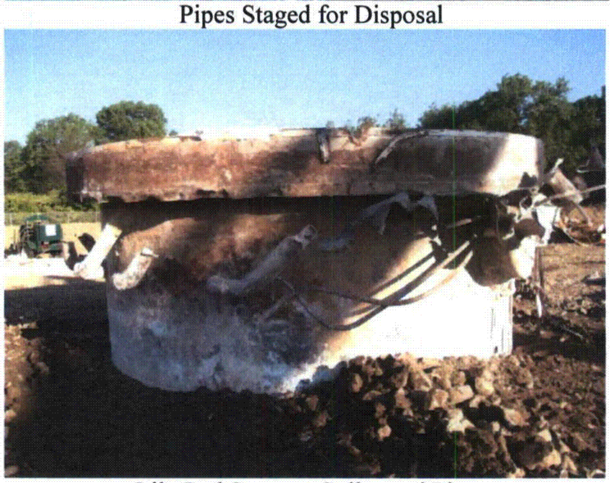


Pipe Survey

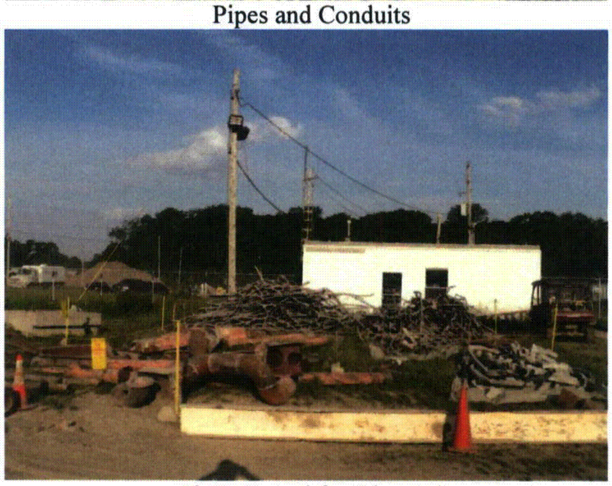
Pipe Survey

Pipes Staged for Disposal

Pipes and Conduits



Lily Pad Support Collar and Pipes



Pipes Staged for Disposal

Exhibit 6, WEMS Outfall Culverts

Plum Brook Reactor Facility

Final Status Survey Report

Attachment 17

Buried and Miscellaneous Piping

Revision 0

Appendix B

Buried and Miscellaneous Piping Location Maps

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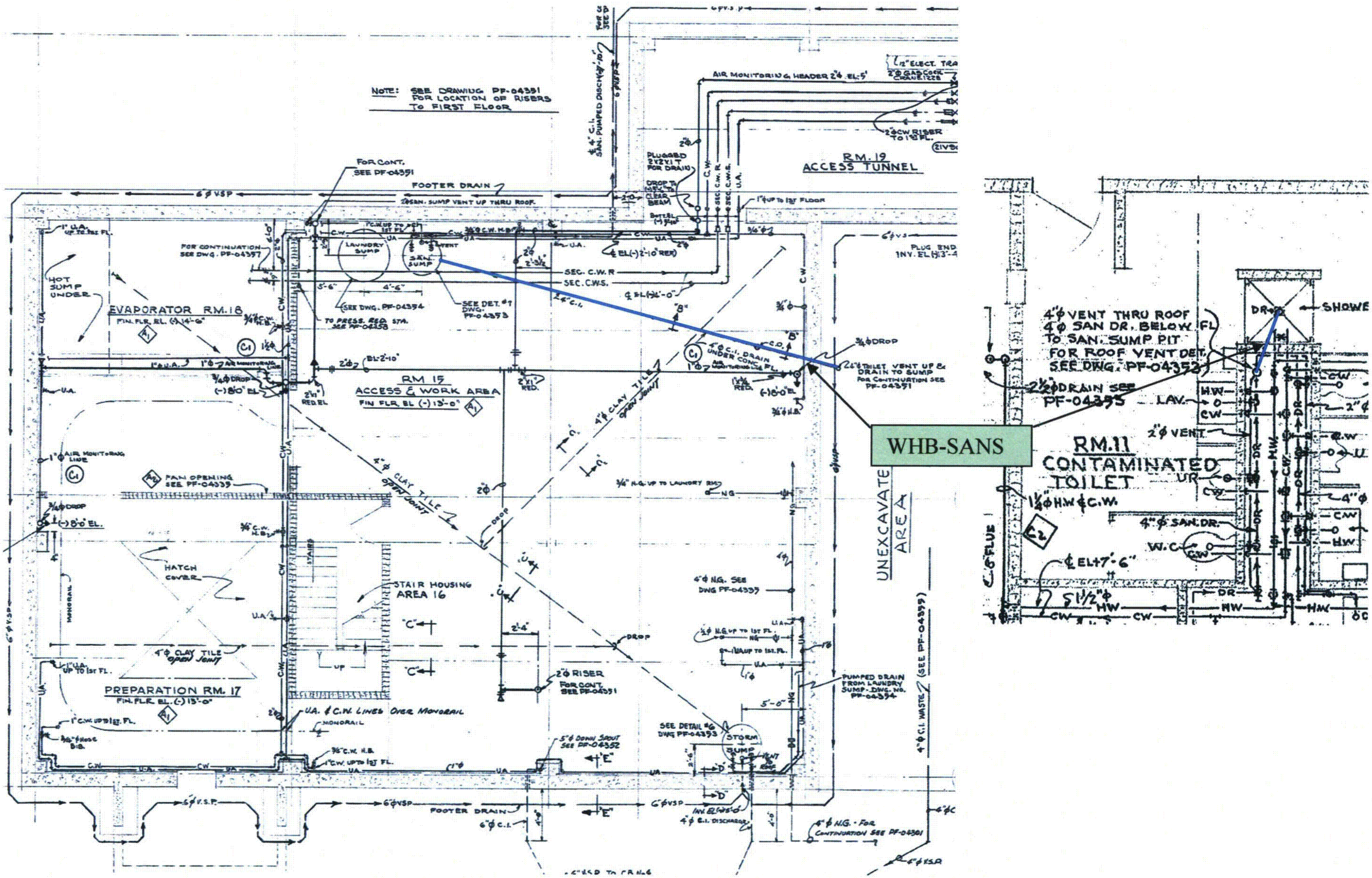

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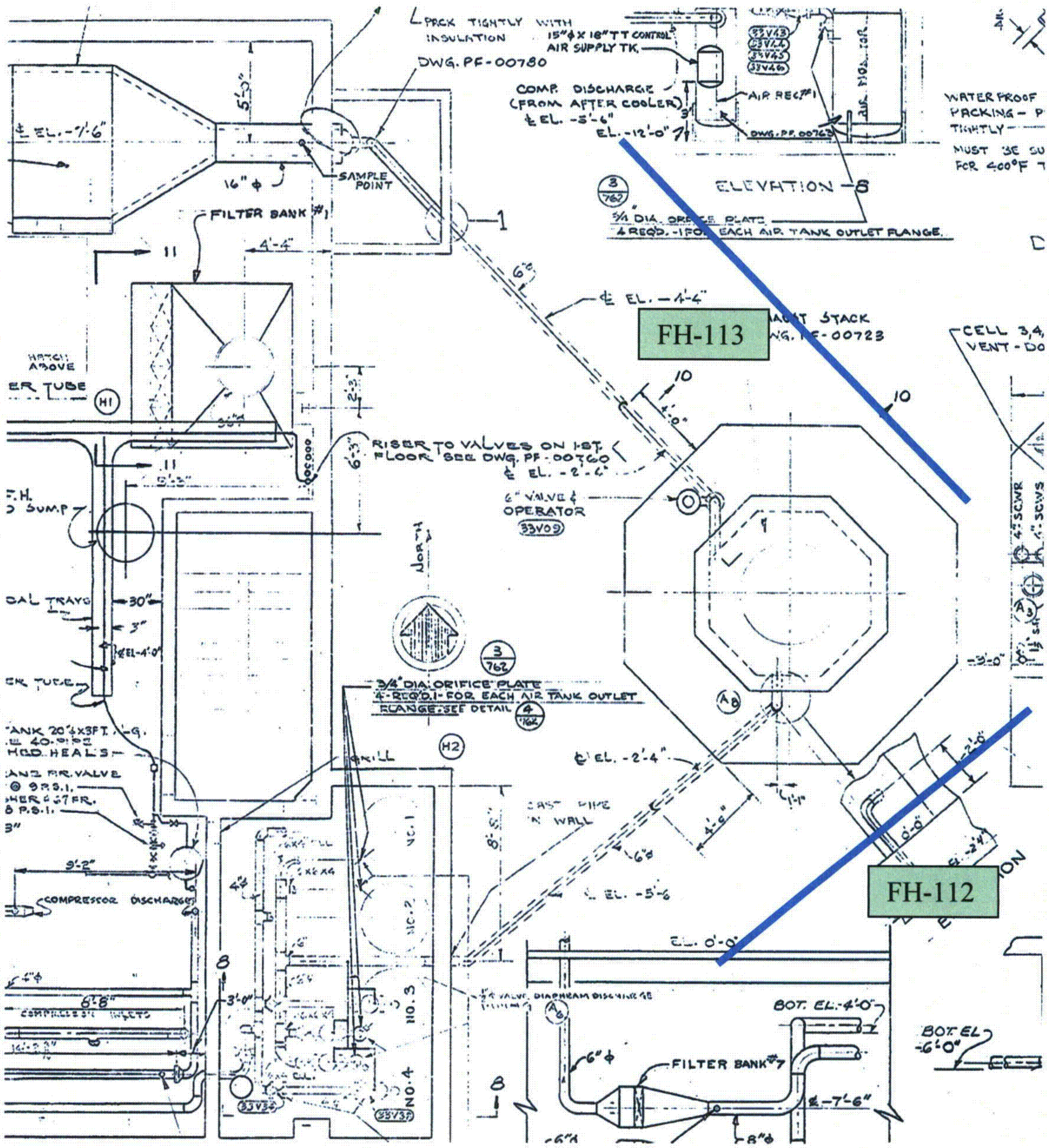

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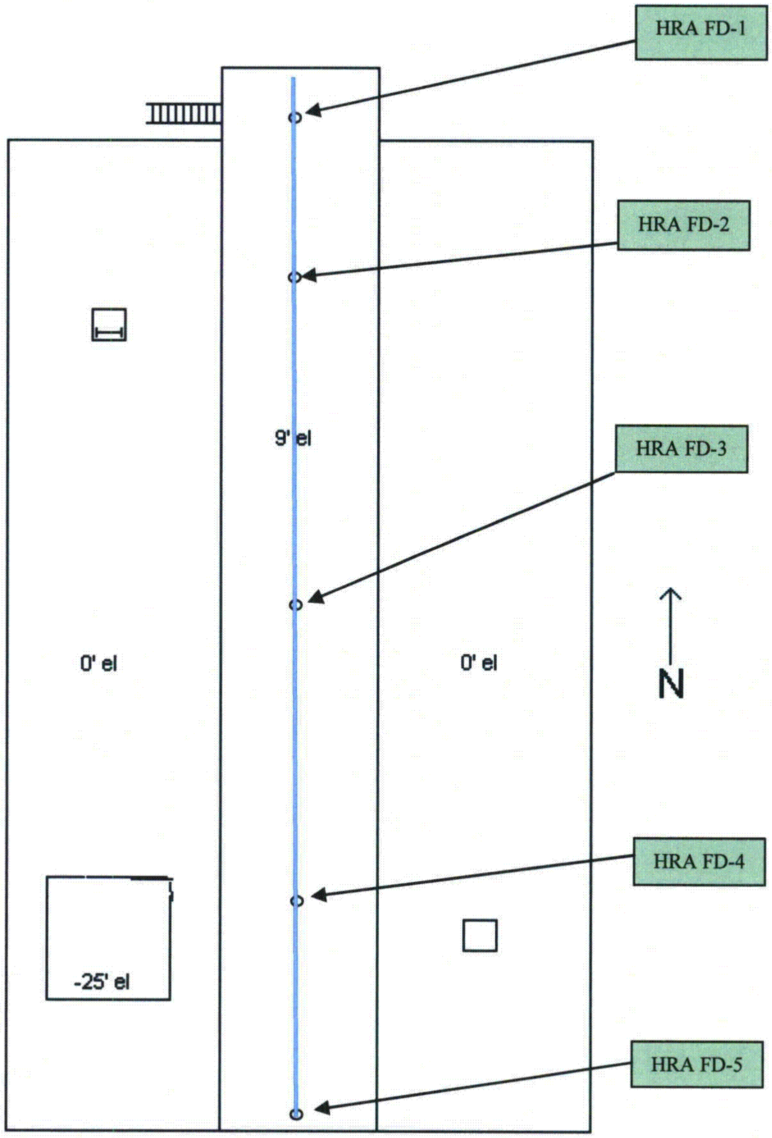

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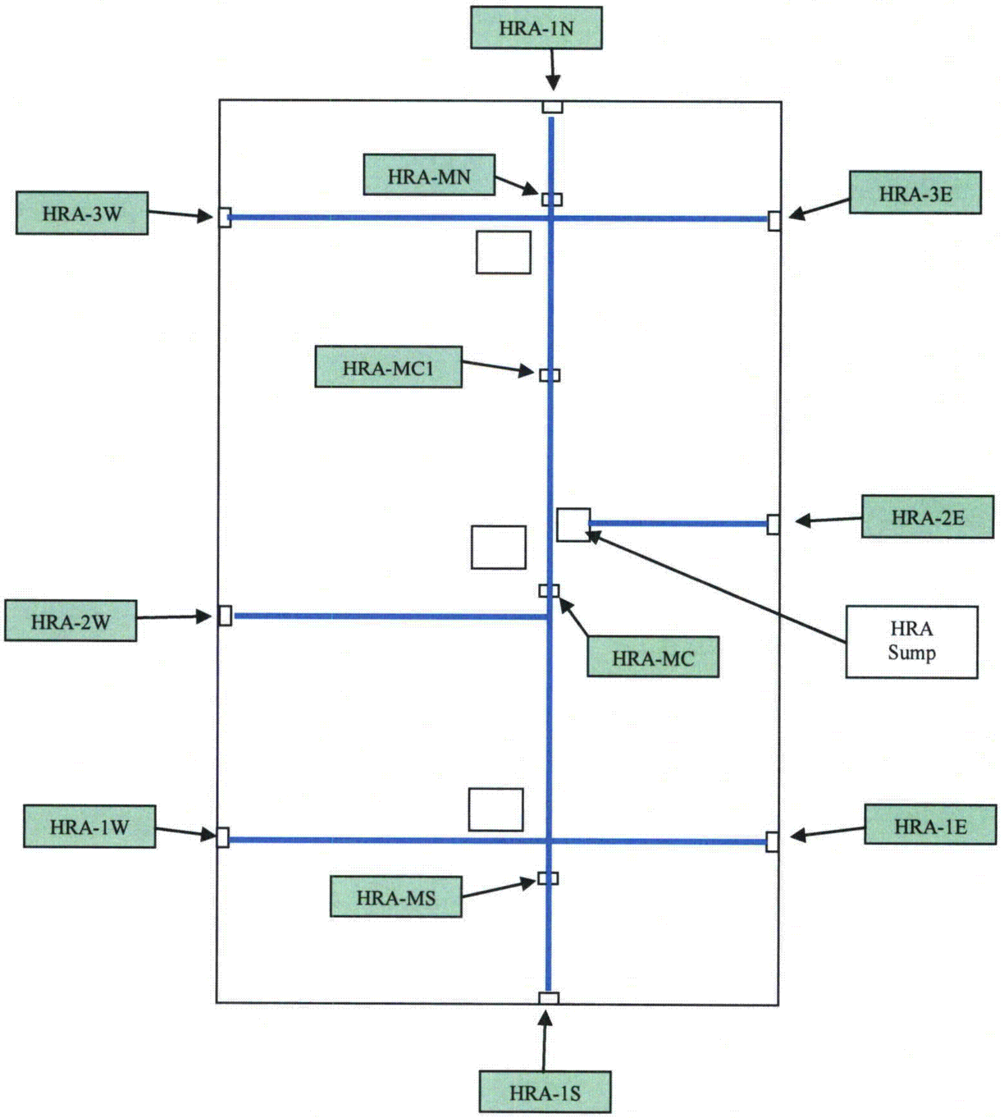

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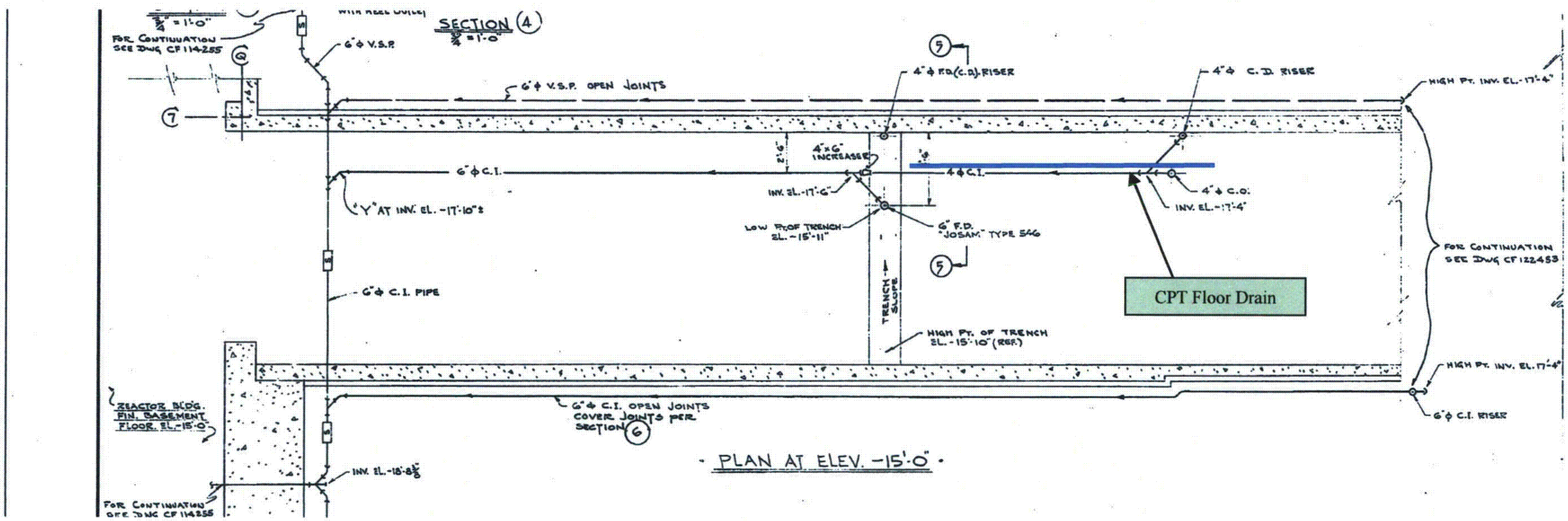

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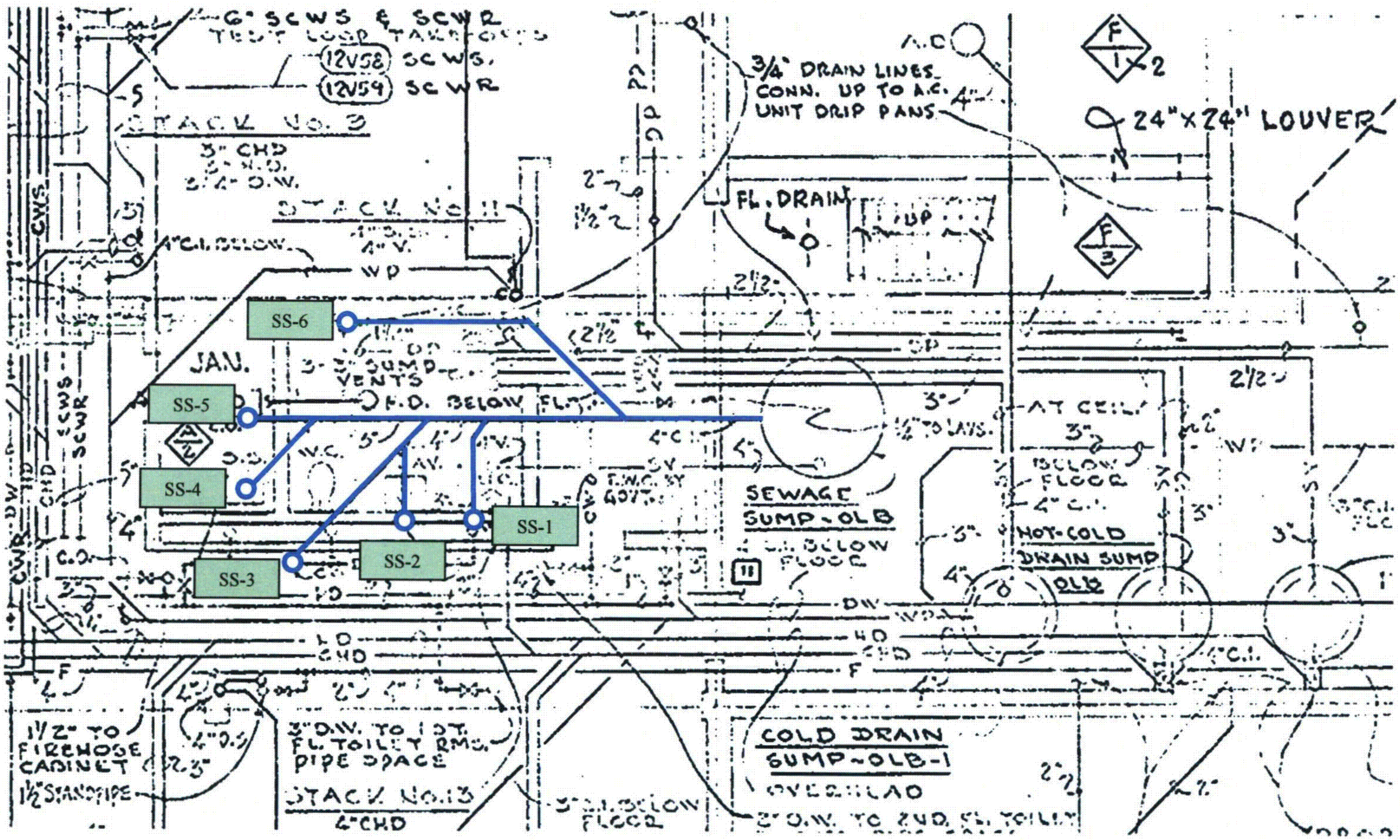

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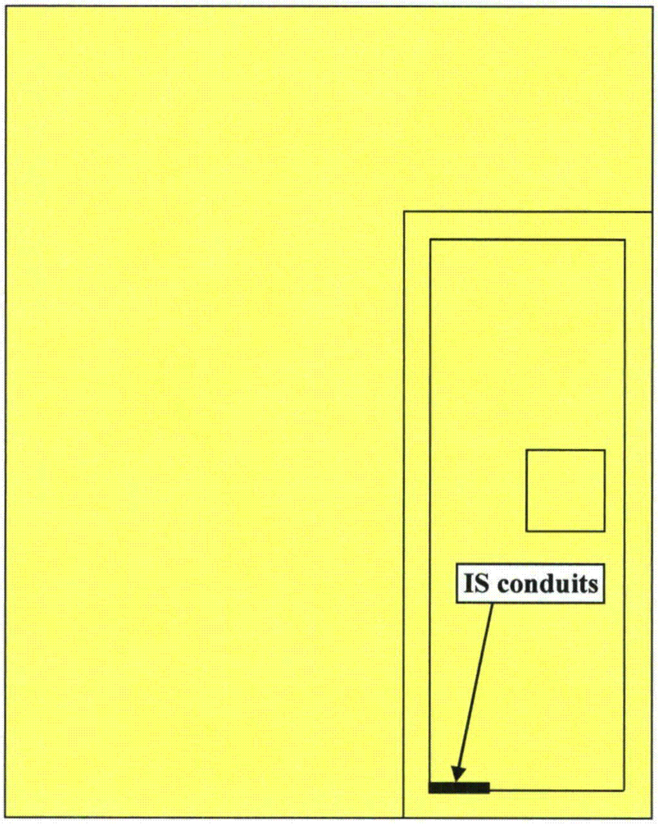

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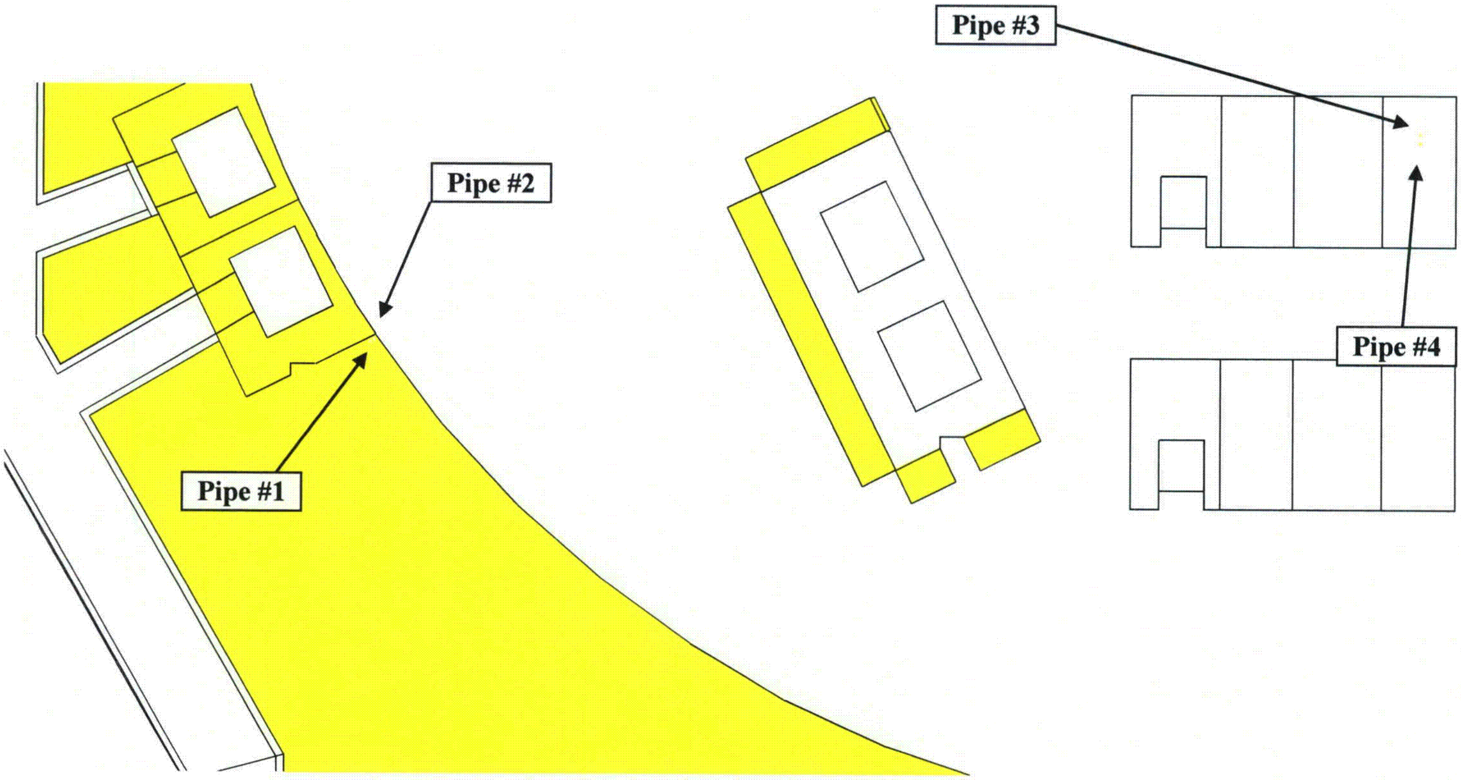

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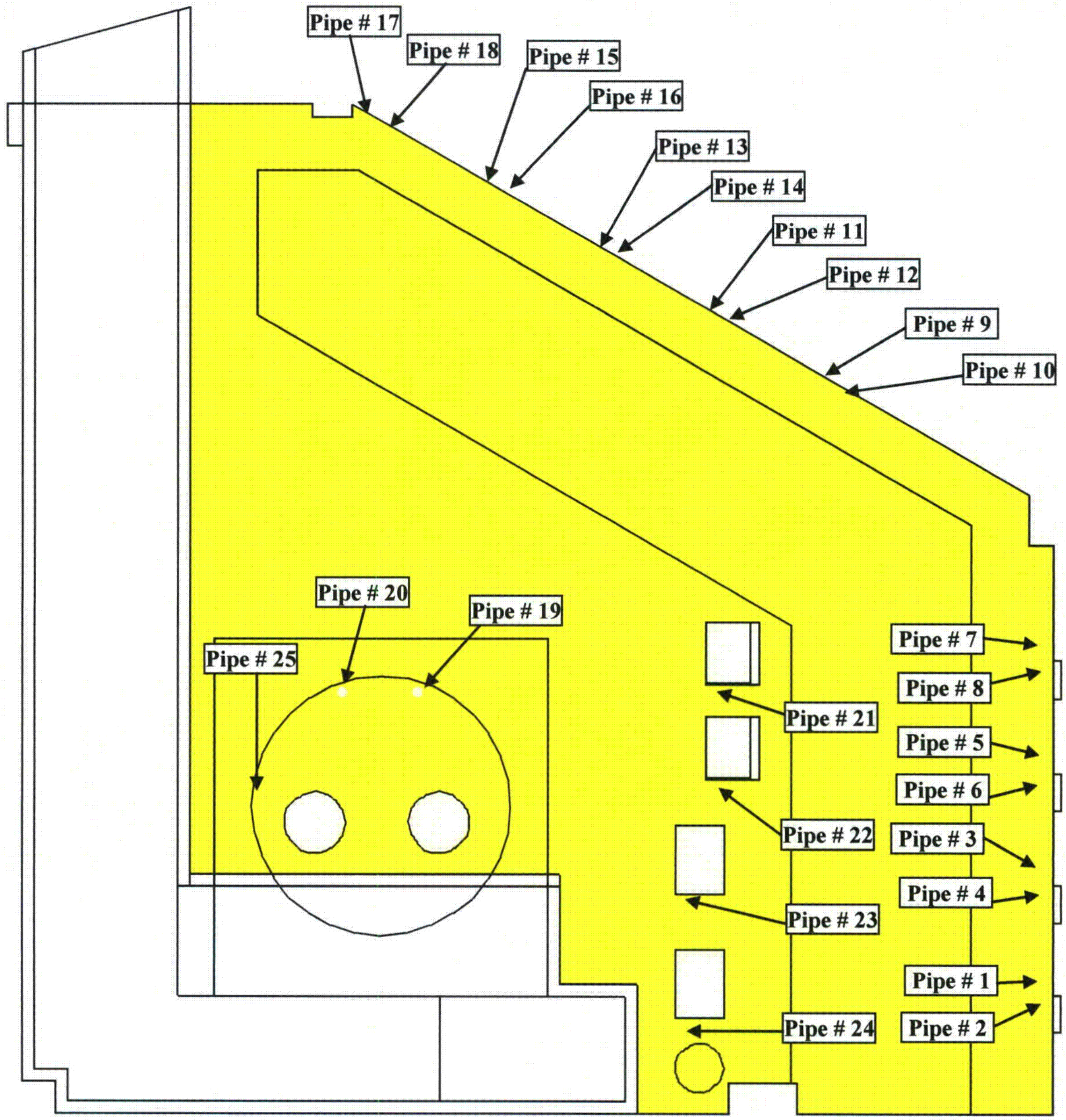

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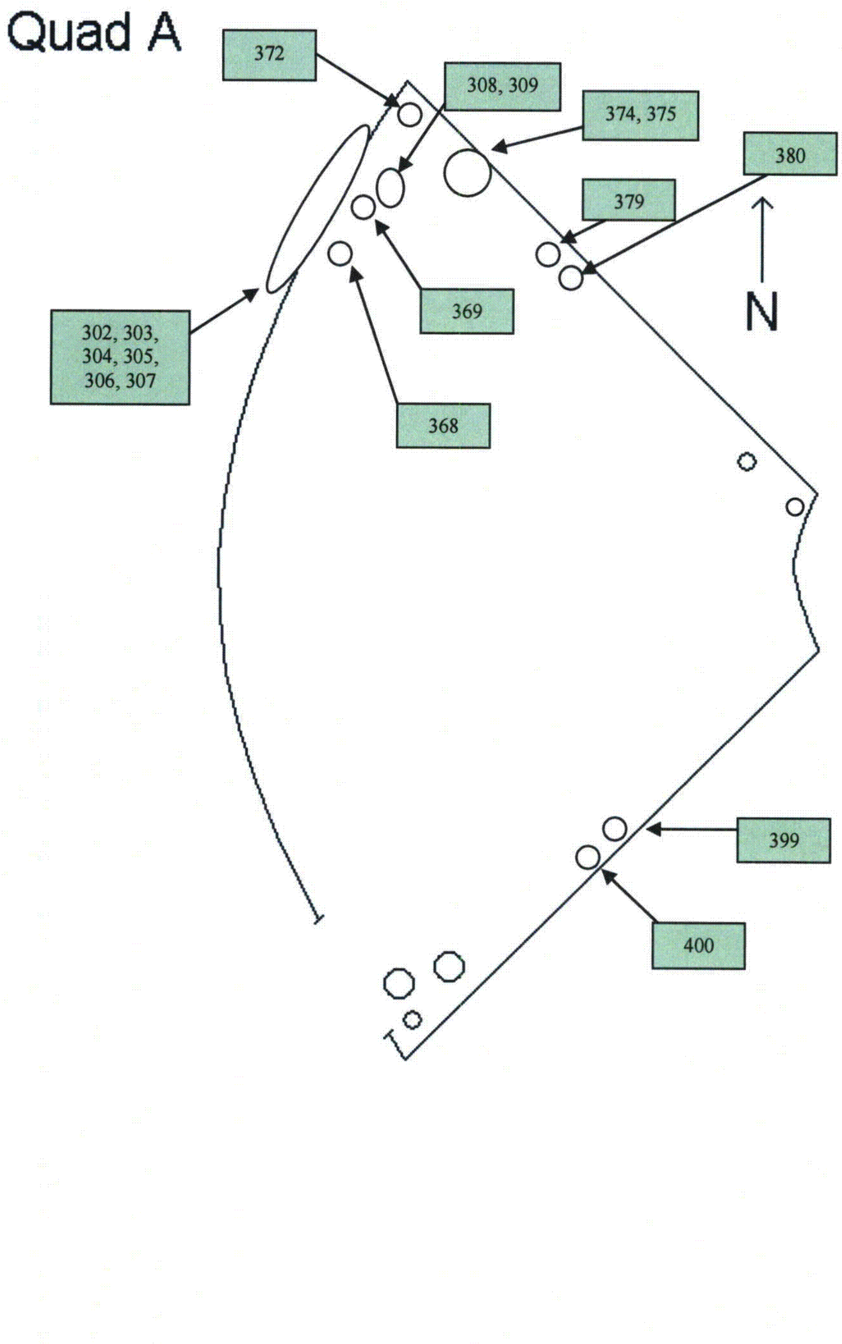

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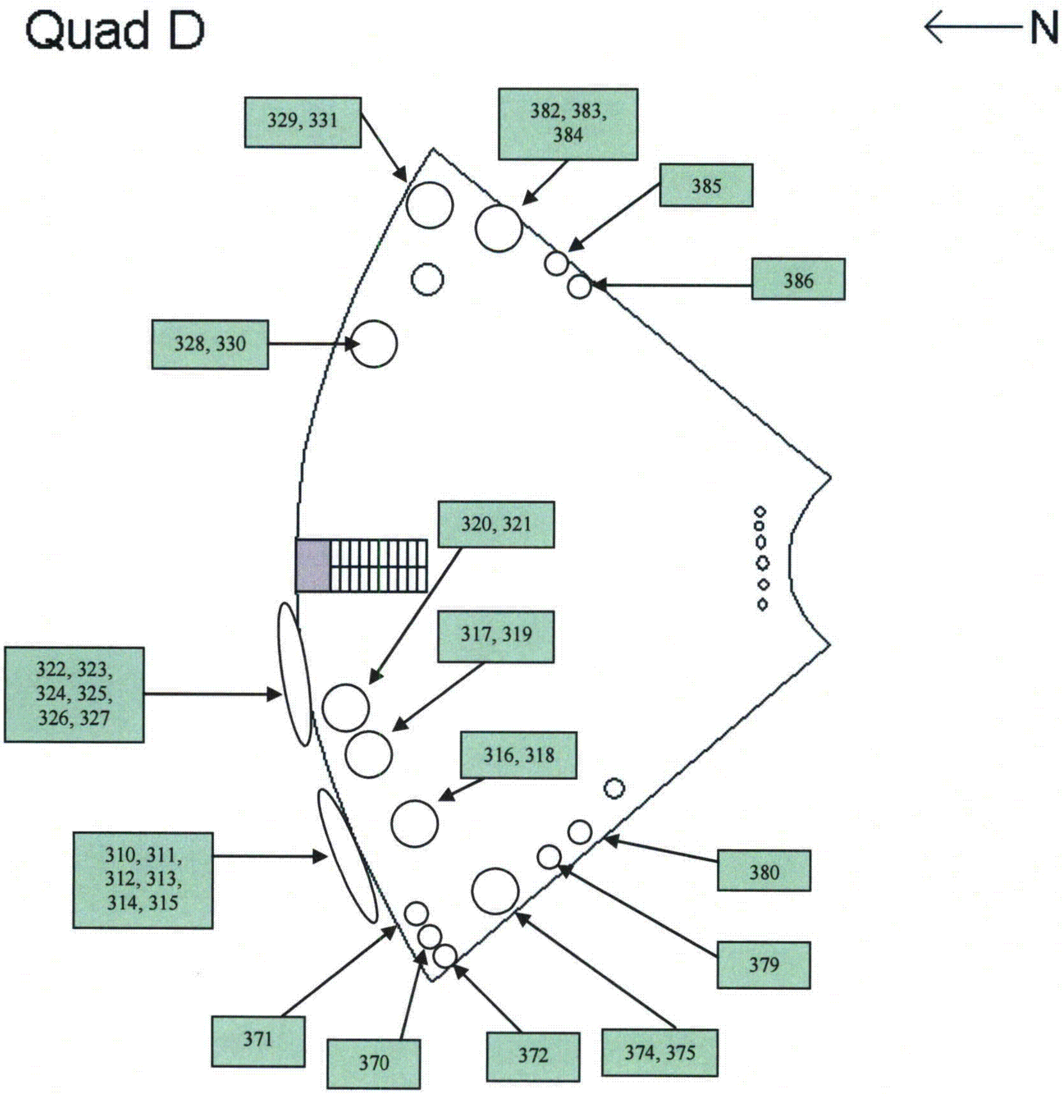

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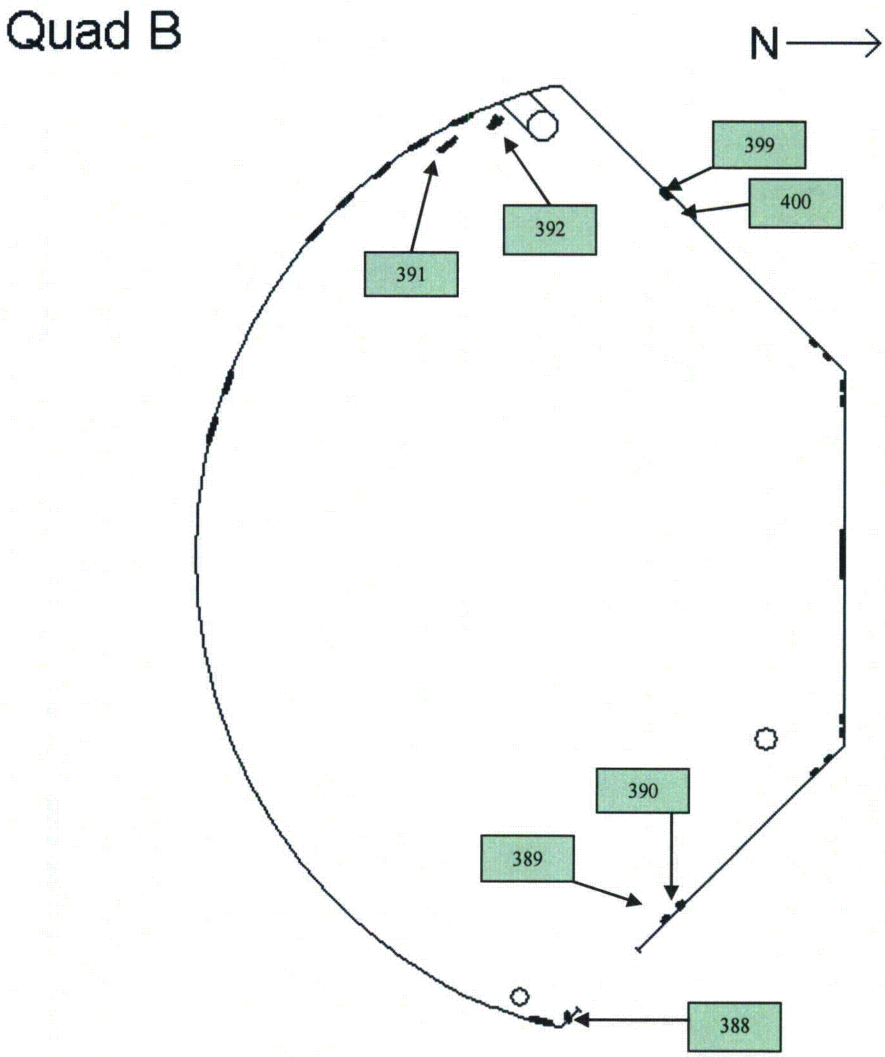

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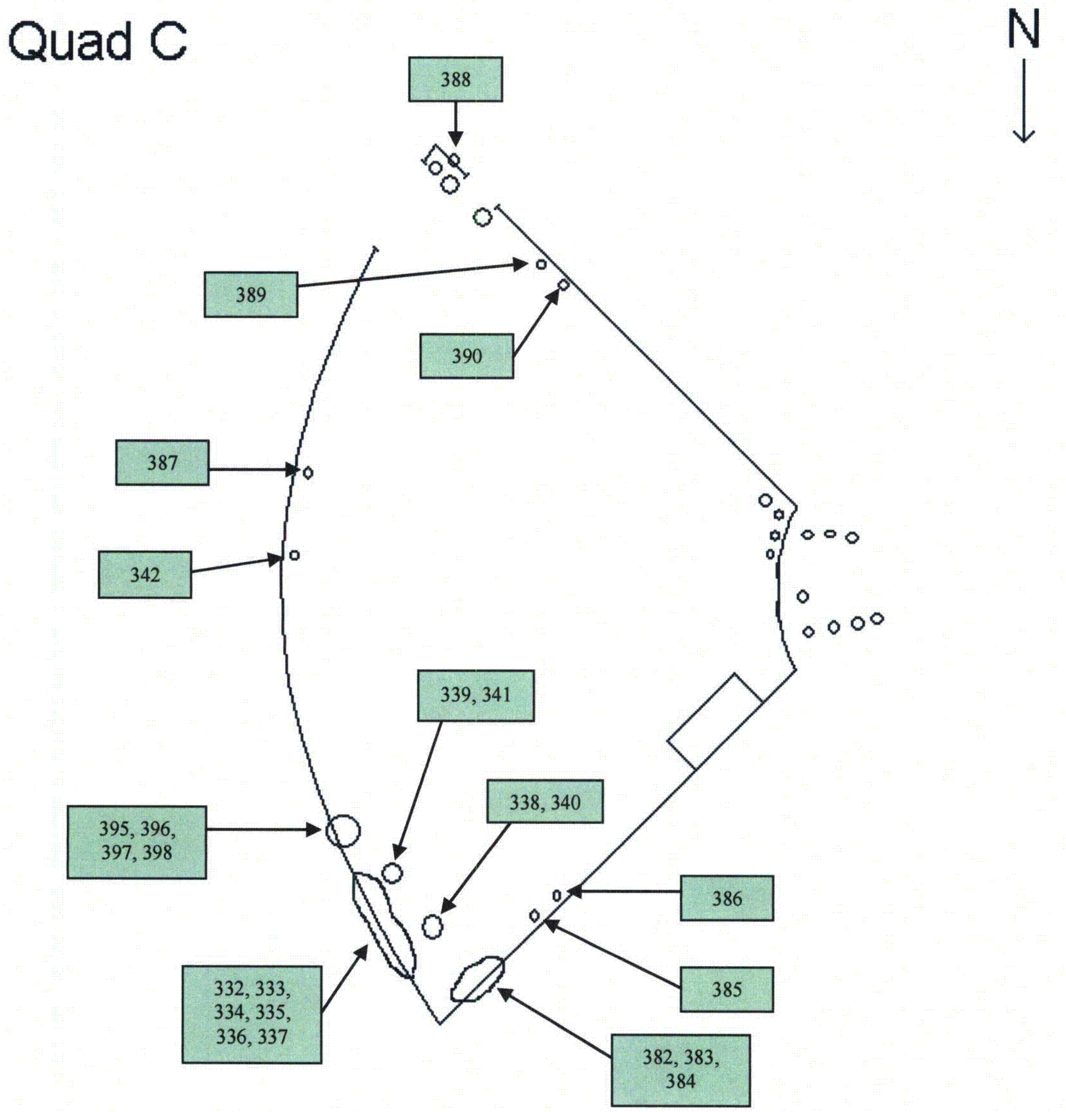

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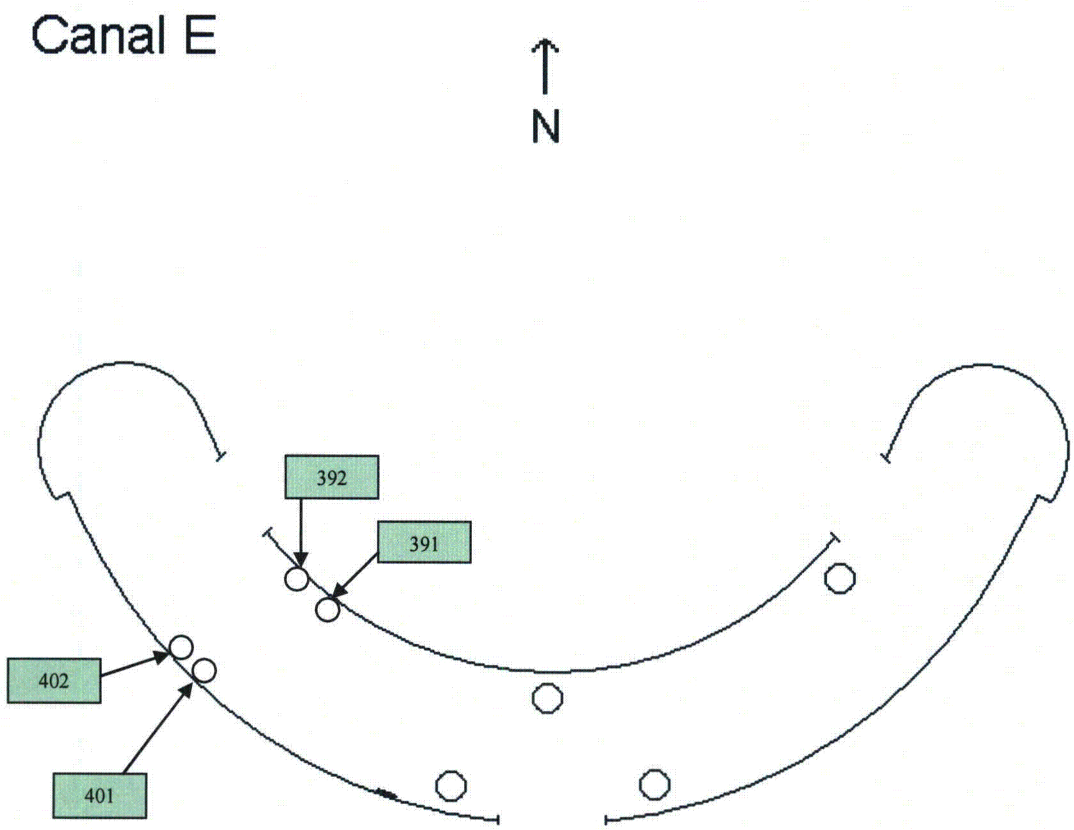

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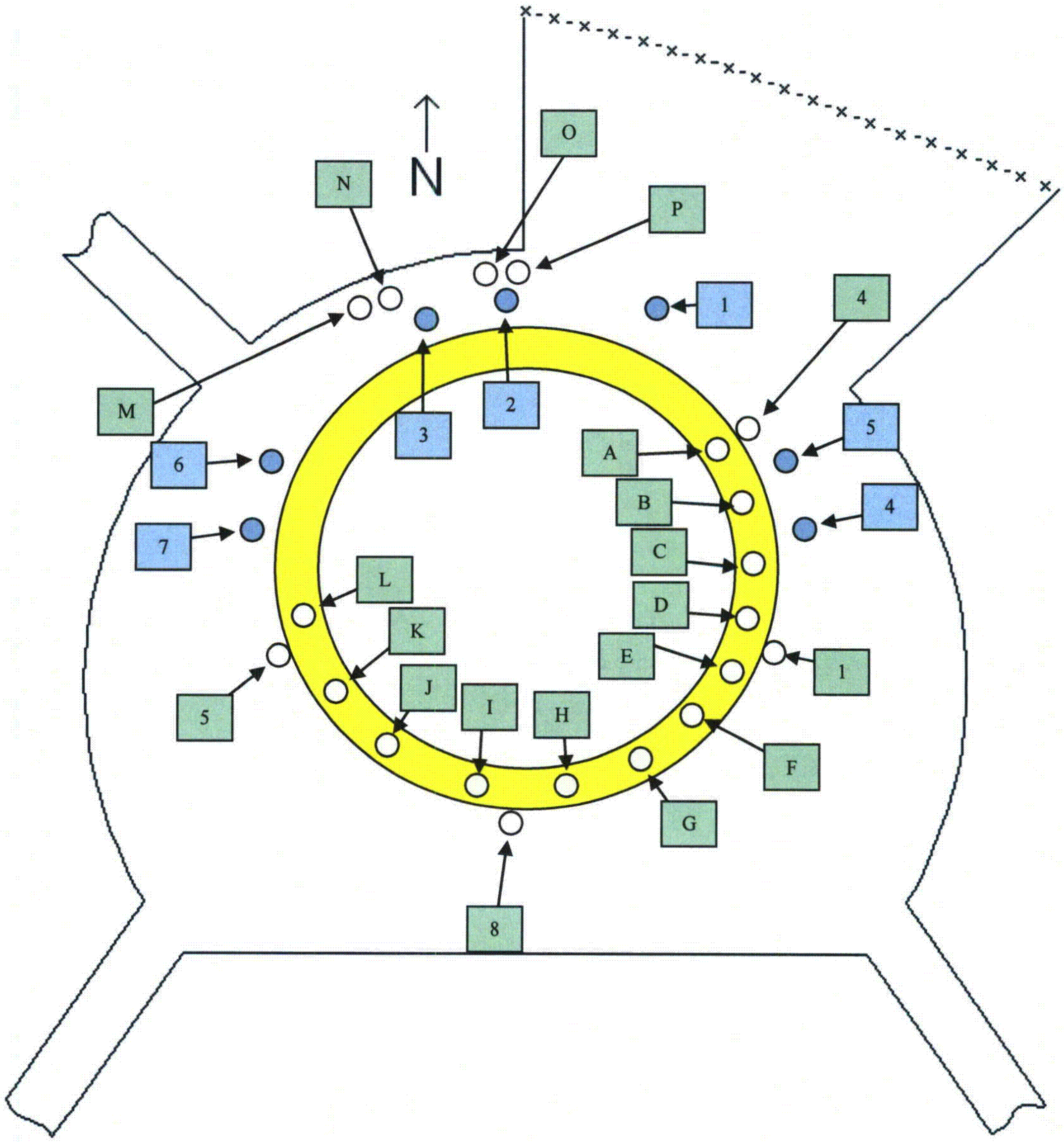

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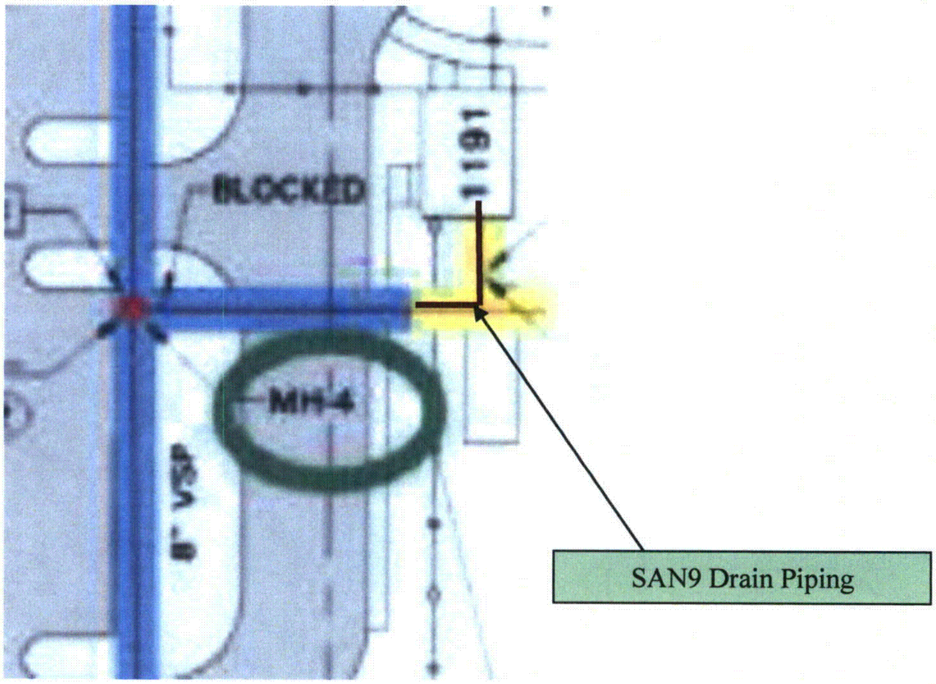

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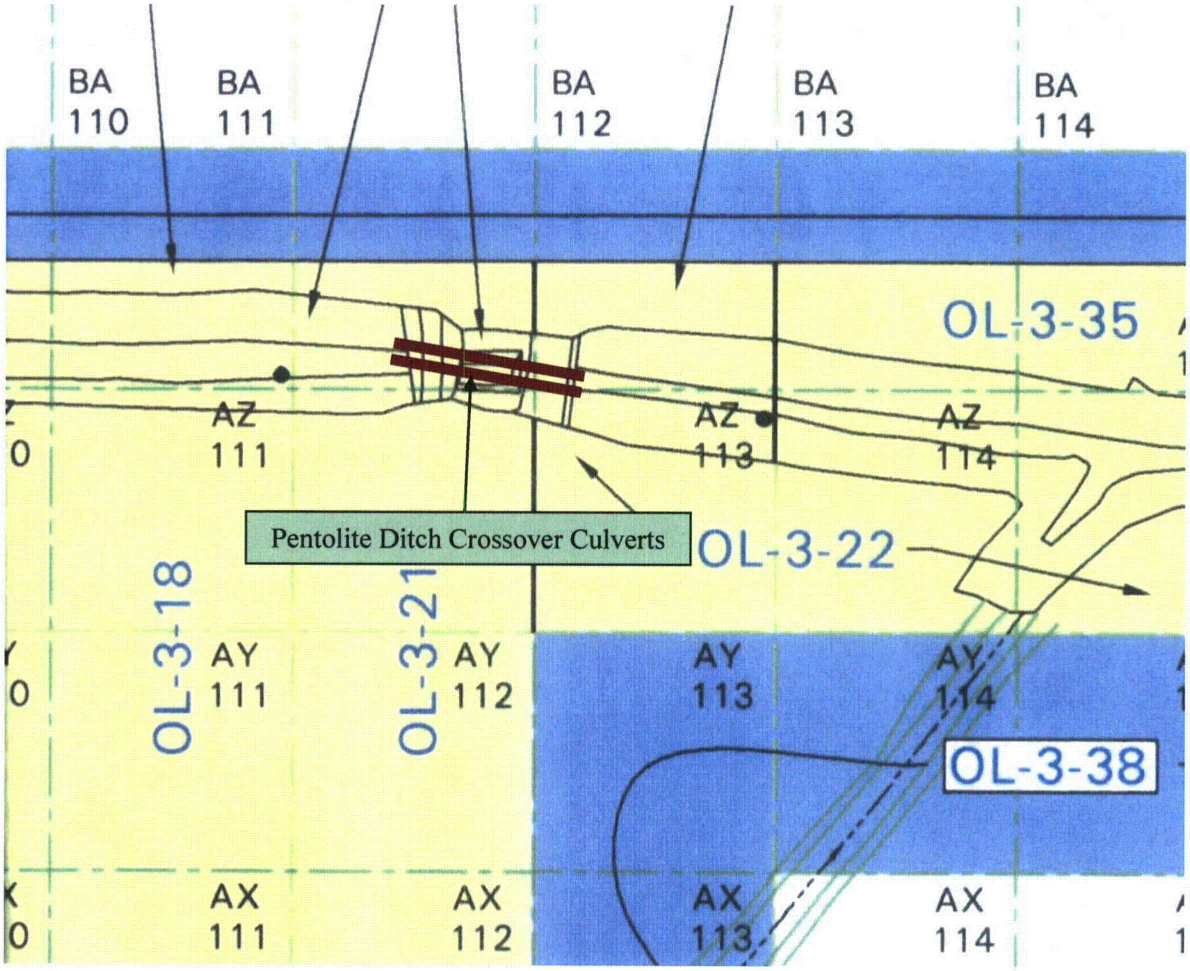

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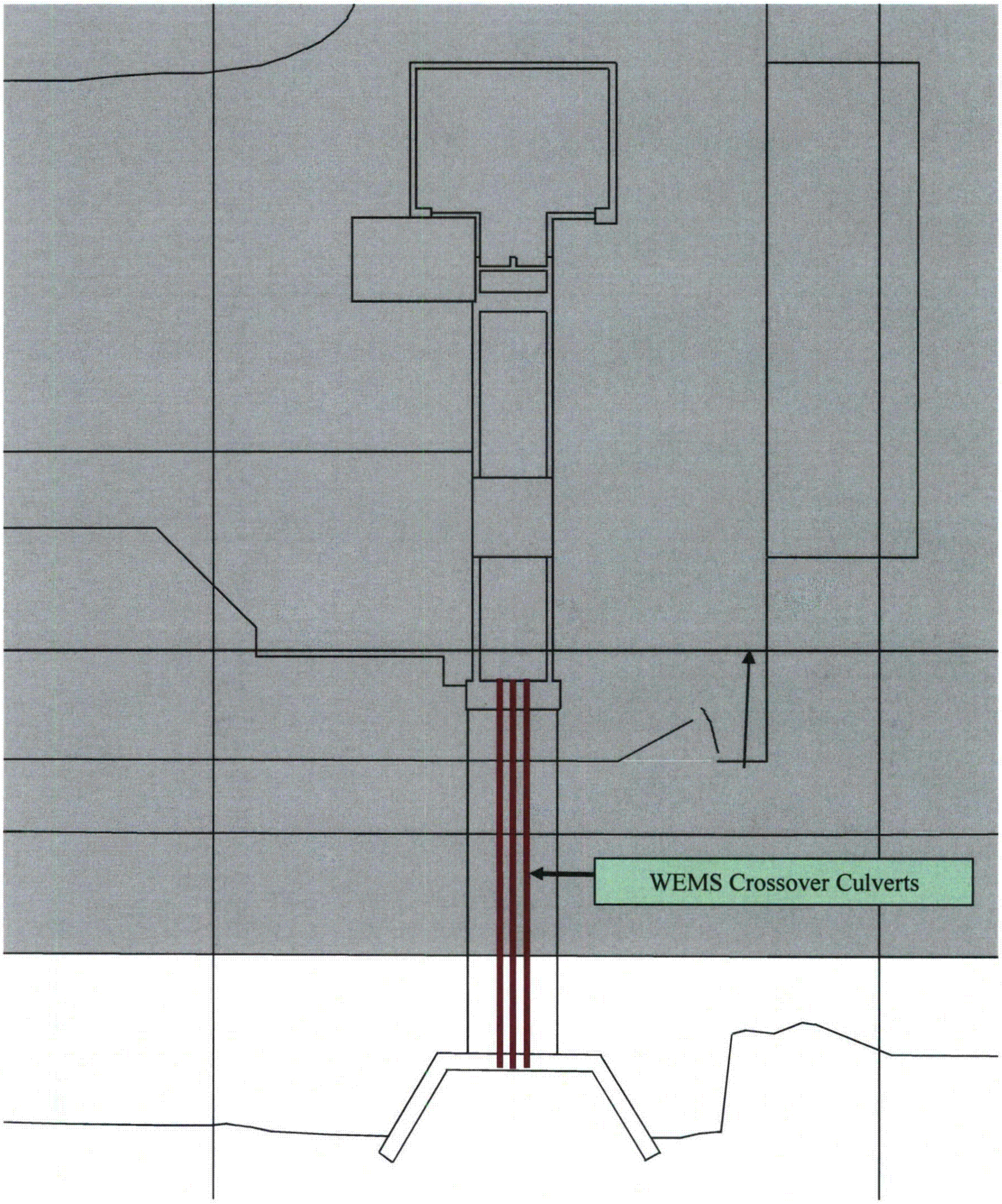

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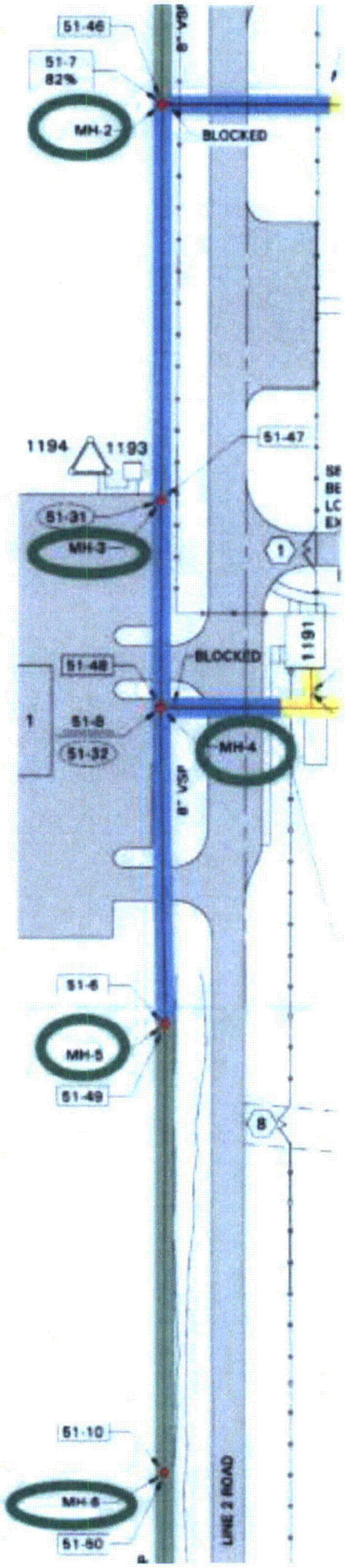

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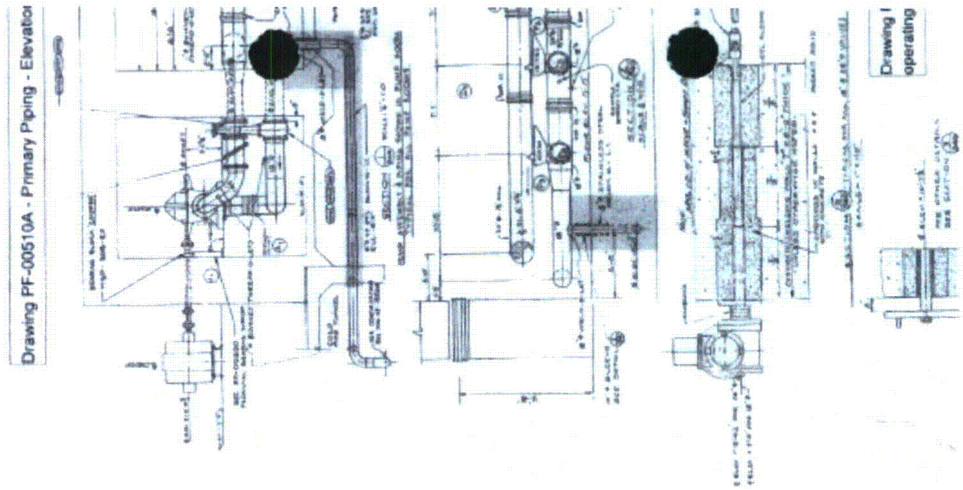

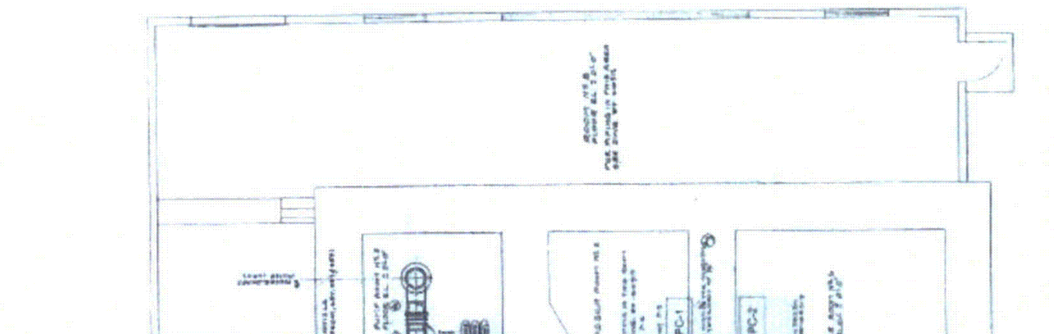

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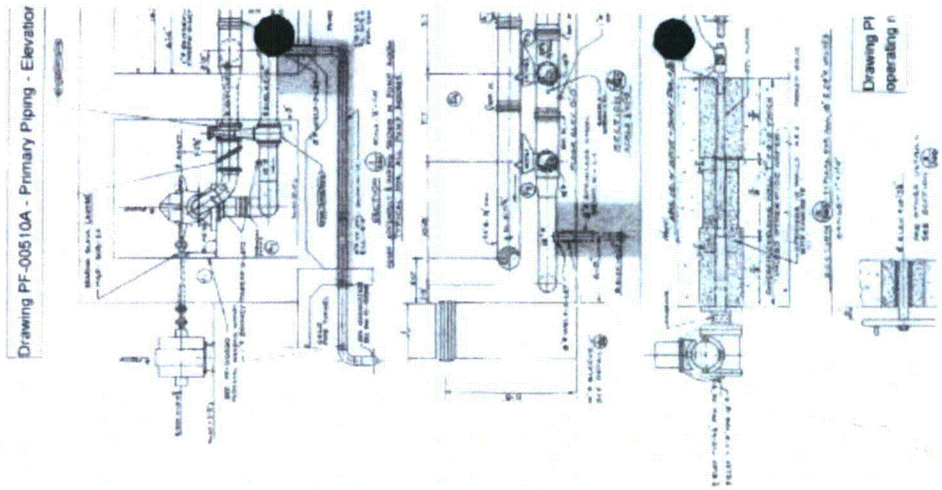

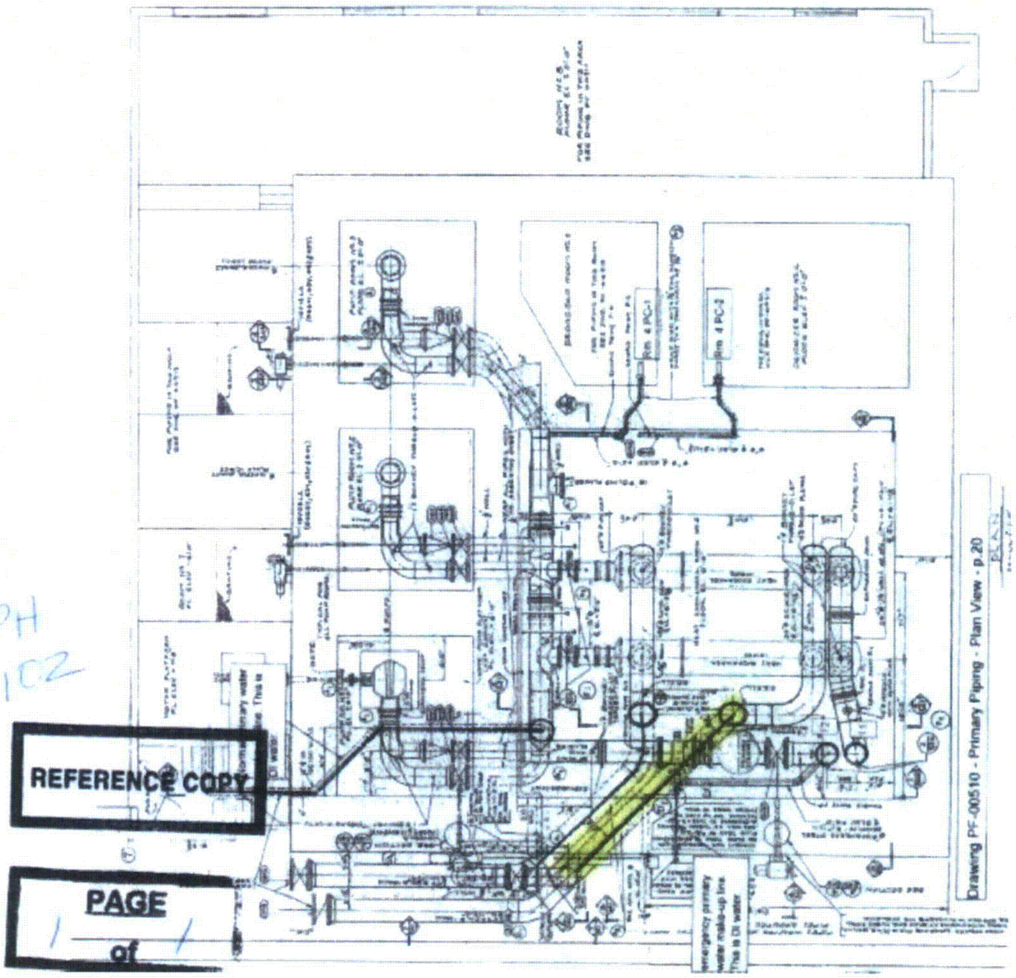

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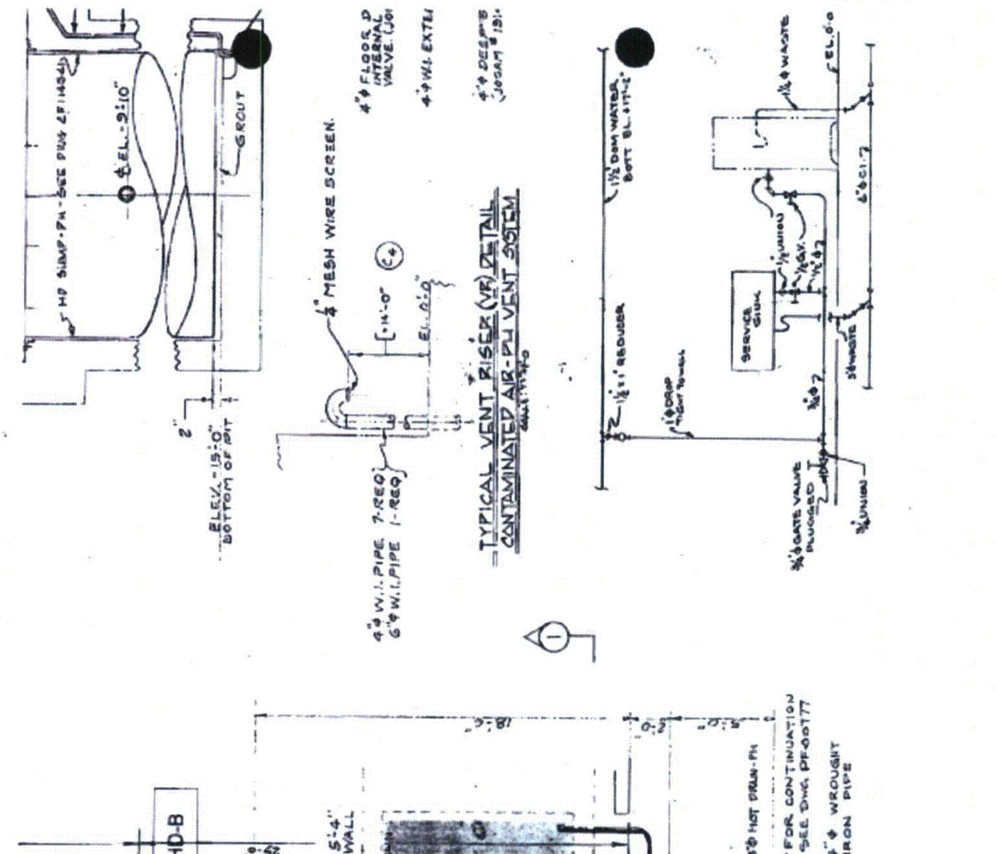

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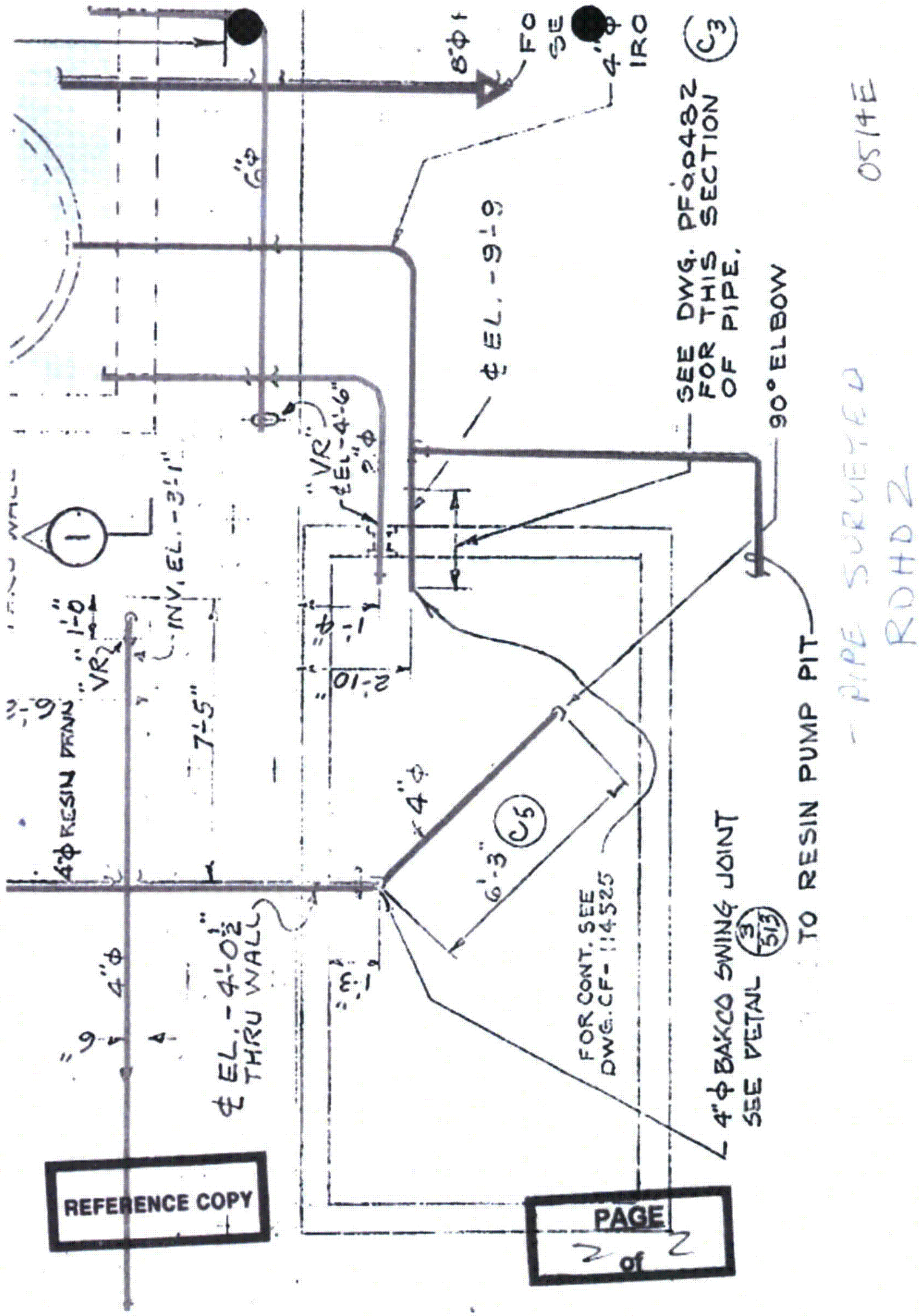

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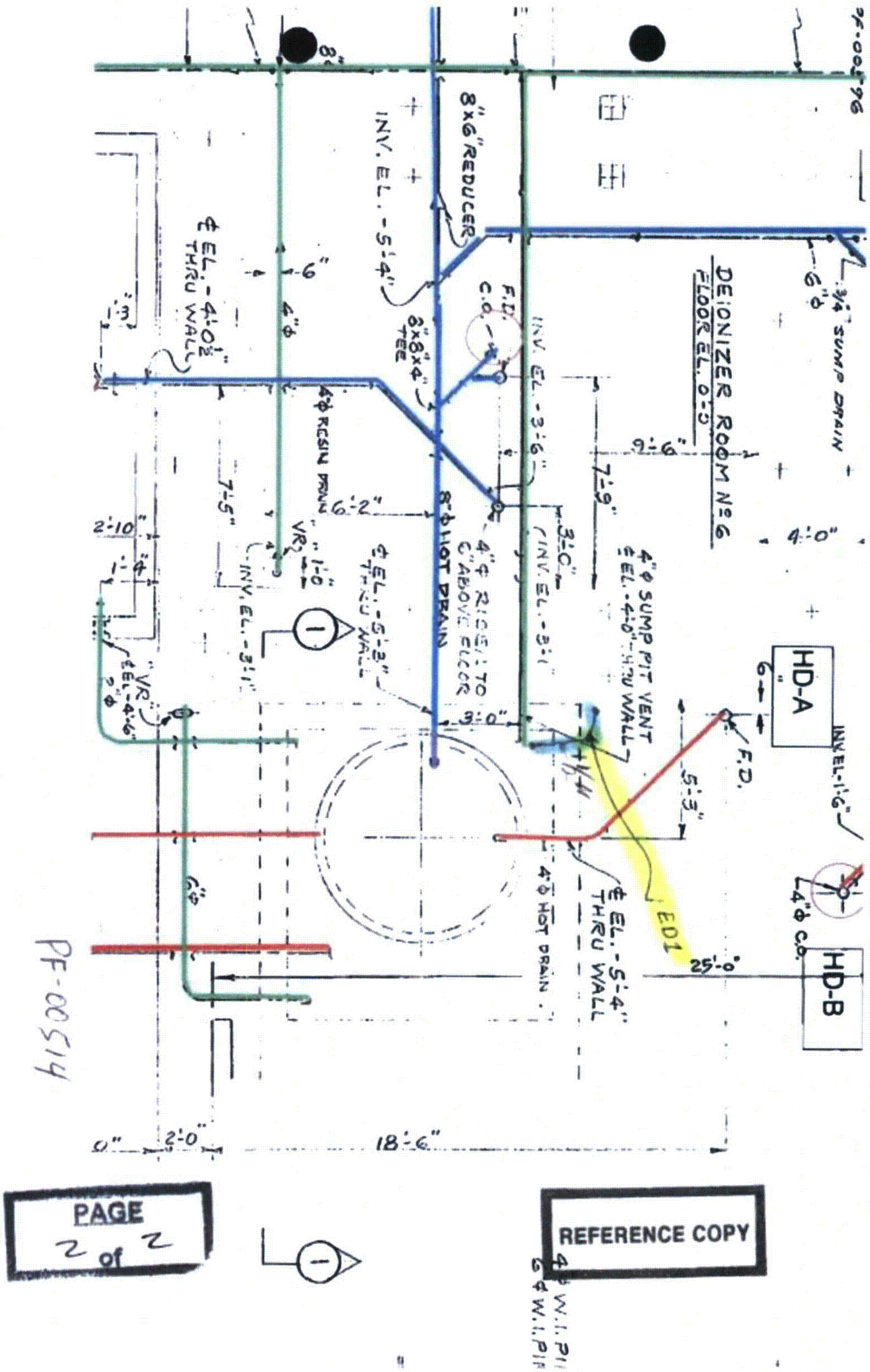

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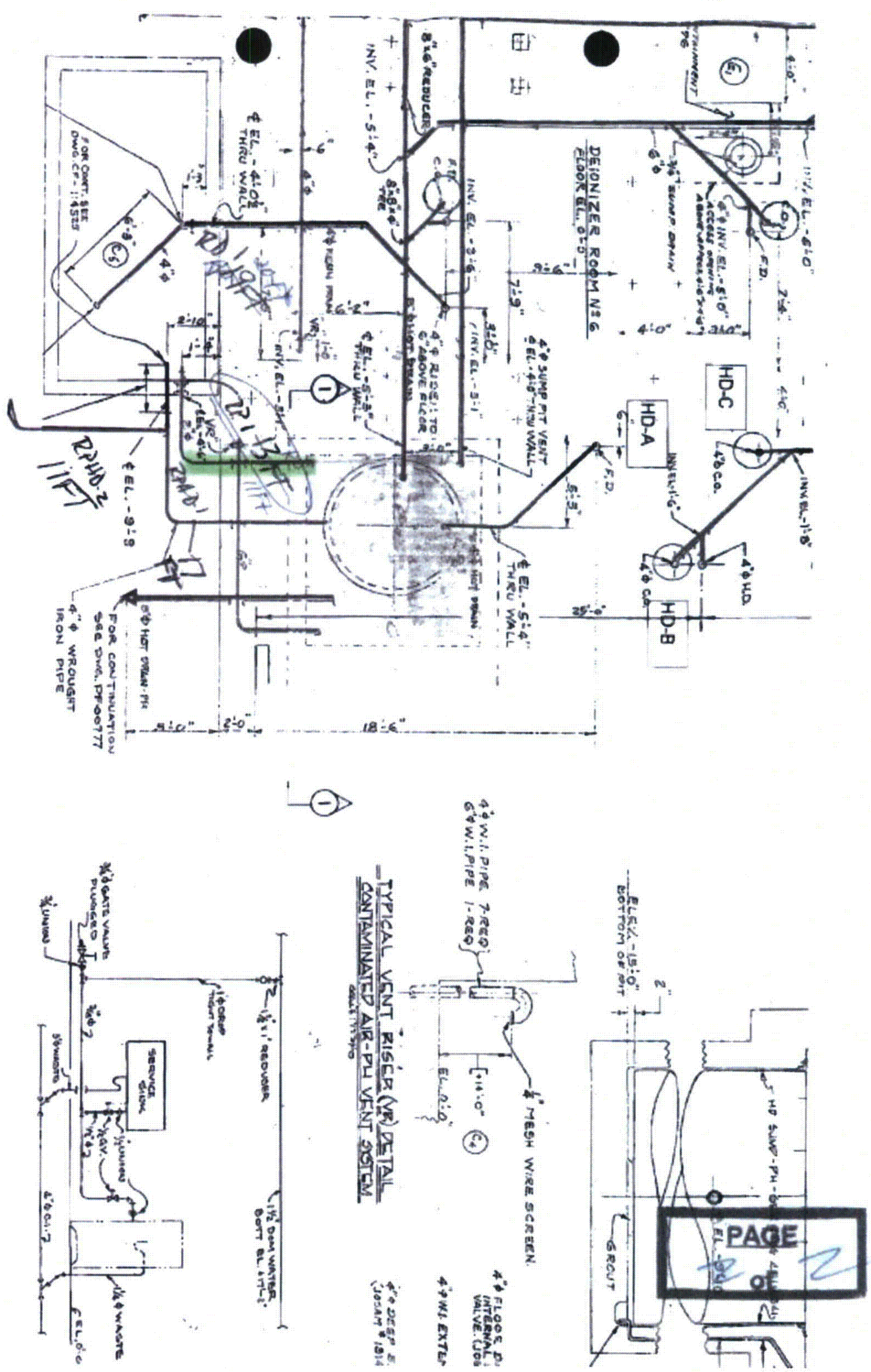

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